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NSWCCD-50-TR-2004/004 May 2004

Hydromechanics Directorate Report

Program Documentation for the Channel Analysis and Design Evaluation Tool (CADET)

By

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NDW-DTRC 5602/51 (Rev. 7-93)

REPORT DOCUMENTATION	*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE May, 2004	3. REPORT TYPE AND DATES COVERED Final

4. TITLE AND SUBTITLE

Program Documentation for the Channel Analysis and Design Evaluation Tool (CADET)

5. FUNDING NUMBERS

W81EWF11798583

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Surface Warfare Center, Carderock Division
Seakeeping Department, Code 5500
9500 MacArthur Blvd.
West Bethesda, MD 20817-5700

8. PERFORMING ORGANIZATION REPORT NUMBER

NSWCCD-50-TR-2004/004

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Corps of Engineers
Waterways Experimental Station
Vicksburg, MS 39180-6199

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLIMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release, distribution unlimited

12b. DISTRIBUTION CODE

The Naval Surface Warfare Center, Carderock Division has developed a software tool, the Channel Analysis and Design Evaluation Tool (CADET), to aid in determining the operational depth of an entrance channel to commercial ports. CADET is a set of computer programs that use probabilistic risk analysis techniques to evaluate the accessibility of a series of channel depths for multiple vessel geometries and loading conditions. The operational depth is governed by many factors, including the geometry of the channel, local environmental conditions, and the hydrodynamic characteristics of the types of vessels that transit the channel. Shallow water vertical motions and the underway squat and trim are included. The wave environment is described using a climatology of local waves. The climatology includes the percent occurrence of combinations of significant wave height, modal period, and peak direction. These values are then converted into directional wave spectra and used to generate the ship motions for that wave condition. The accessibility of the channel for each project depth is then determined through calculating the risk of the ship impacting each project depth and the persistence of that wave condition at the channel. The CADET software distribution includes a MS Windows based program that provides a graphical user interface to the ship and project databases, the analysis software tools, and the results of project studies supporting design alternative analysis. This document provides a short summary of the theory upon which CADET is based, and instructions on how to use CADET.

14. SUBJECT TERMS

Underkeel Clearance, Bottom Touching, Risk Analysis, Port Design

15. NUMBER OF PAGES 73

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unclassified/Unlimited

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ABSTRACT

The Naval Surface Warfare Center, Carderock Division has developed a software tool, the Channel Analysis and Design Evaluation Tool (CADET), to aid in determining the operational depth of an entrance channel to commercial ports. CADET is a set of computer programs that use probabilistic risk analysis techniques to evaluate the accessibility of a series of channel depths for multiple vessel geometries and loading conditions. The operational depth is governed by many factors, including the geometry of the channel, local environmental conditions, and the hydrodynamic characteristics of the types of vessels that transit the channel. Shallow water vertical motions and the underway squat and trim are included. The wave environment is described using a climatology of local waves. The climatology includes the percent occurrence of combinations of significant wave height, modal period and peak direction. These values are then converted into directional wave spectra and used to generate the ship motions for that wave condition. The accessibility of the channel for each project depth is then determined through calculating the risk of the ship impacting each project depth and the persistence of that wave condition at the channel. The CADET software distribution includes a MS Windows based program that provides a graphic user interface to the ship and project databases, the analysis software tools, and the results of project studies supporting design alternative analysis. This document provides a short summary of the theory upon which CADET is based, and instructions on how to use CADET.

ADMINISTRATIVE INFORMATION

This work was funded by the U.S. Army Corps of Engineers Waterways Experiment Station (ACOEWES) under Military Interdepartmental Purchase Requisition (MIPR) W81EWF11798583 and is identified at NSWCCD by Job Order Number 01-1-5500-315.

INTRODUCTION

The analysis and design of a shipping channel is a complex task with many considerations. The determination of the operational depth is one of the technical issues that must be addressed, along with channel width and maneuverability in the channel among others. The Channel Analysis and Design Evaluation Tool (CADET) is a set of computer programs that calculates effective underkeel clearance and bottom touching risk probability for any number of candidate ships and loading conditions over a range of multiple candidate channel project depths. This report documents the basic theory behind the programs utilized by CADET and describes the operation of the

CADET interface program. This report provides a description of the theory behind CADET, the structure and organization of the program and its components, and the operation and use of the software. Descriptions of the input and output files, database files, and auxiliary files are provided in Appendix A.

CADET has been developed by the Naval Surface Warfare Center, Carderock Division (NSWCCD) under contract to the US Army Corps Engineer Research and Development Center (ERDC), Waterways Experimental Station (WES). CADET is an expansion of the technology developed to determine the depth of entrance channels to new homeports for Nimitz Class Aircraft Carriers (CVN 68) [1, 2]* to include many different ports and commercial ships. The technology used in CADET and the CVN 68 channel depth determination was initially developed for the Environmental Monitoring and Guidance System (EMOGS) [3] and explained in the open literature [4, 5]. EMOGS provides operational guidance on the expected underkeel clearance of a vessel, given real time wave and water level measurements or observed conditions at a particular site (port). For each underkeel clearance prediction, EMOGS also calculates the uncertainty and risk of touching the channel bottom for those conditions. Currently, EMOGS is installed at the Naval Submarine Base, Kings Bay, Georgia and the Naval Ordinance Test Unit, Cape Canaveral, Florida and has been in operation for 14 and 8 years, respectively. During this time, no known incident of bottom touching or grounding has occurred.

Both the CVN 68 channel depth determination and CADET differ from EMOGS in several respects. EMOGS evaluates clearance and risk for a single specified ship at one channel depth, using a single specified wave spectra, for a transit in one direction at a specific date and time. Astronomical tide effects on the water level are included and take into account the duration of transit for a given ship speed and entrance channel configuration. Meteorological effects on water level due to barometric pressure must also be included. CADET and the CVN 68 depth determination tool, on the other hand, evaluate clearance and risk for a range of possible water depths. In addition, CADET evaluates the entrance channel depths for any channel configuration. Annual local wave statistics are used to determine the accessibility of the transit channels, expressed in days per year. No astronomical or meteorological tide effects are included since, for design purposes, a transit could occur in either direction at any time.

METHOD FOR DETERMINING OPERATIONAL CHANNEL DEPTH

UNDERKEEL CLEARANCE CALCULATION

CADET calculates the vertical underkeel clearance of a specific ship, commercial or naval, at a specified port location, and provides information to aid in determining the optimum depth to dredge the channel. The optimum dredge depth is defined as the shallowest depth that allows the maximum days of access for any given year at that port location. The accessibility of the channel is determined by calculating the vertical underkeel clearance and the risk of the vessel touching the channel bottom under all wave conditions that are present at the location under

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* References in brackets appear on page 37.

consideration. The general rule followed is that if the risk of the vessel touching a flat channel bottom is less than 1 in 100 during a given transit, then the port is considered accessible for that channel depth. The number of days per year the channel is accessible is dependent upon the persistence of the local wave conditions. This persistence is obtained from the local wave climatology.

The dynamic underkeel clearance of the vessel is influenced by five major parameters. These parameters include the static draft and trim of the ship at rest, the underway sinkage and trim, and the wave-induced vertical motions, the hydrologic factors of depth of the channel at Mean Lower Low Water (MLLW) (referred to as the project depth), and the change in water level due to the astronomic tides that are in the area. Because CADET is primarily a channel design tool, ephemeral parameters such as meteorological tides are not factored into the calculation. Also, because CADET only considers the vertical underkeel clearance, there is no calculation of the channel width or bank effects.

Figure 1 depicts the major parameters considered when calculating the vertical clearance of the vessel in the channel. The static underkeel clearance is the difference between the nominal channel depth and the static at-rest draft of the vessel. Static trim must also be taken into account. This is done by requiring entries of the draft at the bow and stern of the ship. As the ship travels at speed along the channel, the ship both sinks and trims due to a pressure field between the hull of the vessel and the channel bottom. The amount of sinkage is dependent upon the speed of the vessel and the amount of underkeel clearance. A table of sinkage versus ship speed and underkeel clearance is developed outside of CADET and used to account for this parameter.

The wave induced ship motions of heave, pitch, and roll can also be a limiting factor in the underkeel clearance during a channel transit. The magnitude of the vertical displacement at a point on the ship is dependent upon the height and period of the waves in the channel, the ship speed, the relative ship heading to the waves, and the channel depth. Because the root mean squared (rms) motion calculated from the wave condition may not provide the largest vertical excursion due to phase differences, a motions allowance is calculated. This calculation yields an extreme motion with a risk of 1 in 100 that it will be exceeded for the given set of wave conditions. Following Dalzell [6, 7], the motions allowance, A_j, is calculated in accordance with the results of high order statistical theory due to Ochi [8]. The formula for motions allowance follows the form of equation (1).

$$A_j = \sigma_j \sqrt{2 \ln \left[\frac{T_{ex} \sigma_{vj}}{2\pi\alpha\sigma_j} \right]} \tag{1}$$

where σ_j is the standard deviation of the vertical motion at the j^{th} location on the ship, α is the risk parameter, normally taken to be 0.01 (1/100), and σ_{vj} is the standard deviation of the velocity of vertical motion at location j. The motions allowance, static draft, T_j, and the change in draft due to squat, S_j, are subtracted from the channel depth at MLLW or the project depth being considered, E_{ch}, and the effective water level due to astronomic tide, E_a, to yield the minimum net effective underkeel clearance, C_{eff}, considering each of the j locations.

$$C_{eff} = E_{ch} + E_{at} - (T_j + S_j + A_j) \quad (2).$$

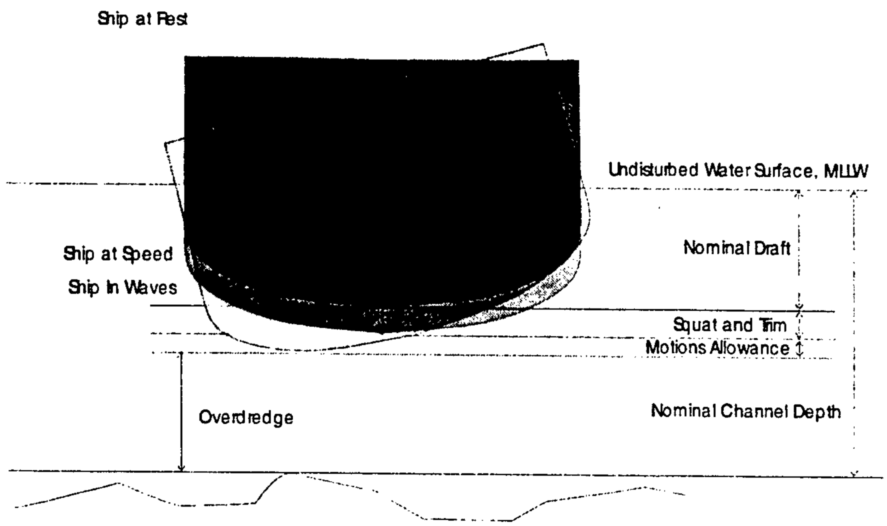


Figure 1. Cross Section of a Ship in a Channel

UNCERTAINTY AND RISK ANALYSIS

Each of the parameters in equation (2) has inherent uncertainties. These uncertainties are fully explained in Dalzell [6, 7] and Silver [3] and summarized here. Table 1 shows the uncertainty, variability and bias, in each of the major parameters that make up C_{eff} for a large Naval vessel. First, the channel depth for CADET has no bias or variability because it is a determined parameter. Second, the uncertainty in the static and dynamic drafts come from the estimation of the draft at the pier, from the draft marks, and the program that calculates the sinkage and trim. The error band in the static draft is assumed to be known within a range of ±1%. The critical points of the bow, stern and bilge therefore have an error band of ±1.8 feet at the bow and stern and ±0.6 feet at the bilge. The sinkage estimate is usually based on an analytical method or model test results. The uncertainty in the sinkage stems from the scatter of the data from model tests and how well the calculated results fit the model test results. This relates a variability of the sinkage parameter of ±0.4 feet with no bias as shown in Table 1. The final two parameters are the wave statistics and the wave-induced motions. The wave statistics are usually generated from hindcast wind models, and then the waves are transformed from offshore to the channel with a shallow water wave model. Most models are validated with buoy data. The bias and variability shown in Table 1 for the transformed wave spectra assumes a measurement bias and large variability in the wave input. The usual models for global ocean wave prediction using wind hindcast data introduce a bias of ±0.6 feet, and an average root mean square error of 2.6 feet which translates to an error band of about 80%. The variability of the wave input, especially wave height, is the main driver of the variability in the

motions estimates. There are also uncertainties in the calculation method of the response amplitude operators. The shallow water motions calculation of the Navy ships was a software program that was a hybrid of the Navy Standard Ship Motion Program (SMP). This hybrid was validated through both model testing and comparing the predicted motions with those measured full-scale [9]. The motions of the commercial ships used in CADET were computed through the shallow version of SCORES [10, 11]. The bias and uncertainty shown in Table 1 reflect those of a large Navy ship. Once the predicted motions of commercial ships are compared with full scale measurements, the bias and variability could change. However, a large component in the uncertainty and bias in the motions calculation comes from the uncertainty in the wave measurement. Therefore, the difference in the uncertainty of the motions between the commercial ships and Navy ships may be small.

Table 1. Summary of Bias and Variability in the Major Parameters Considered

(all values represent the $\pm 2\sigma$ range)

Parameter	Bias	Variability
Channel Depth	None	None
Static Draft		
Bow and Stern	None	1.8 ft (0.5 m)
Bilge	None	0.6 ft (0.2 m)
Squat	None	0.4 ft (0.1 m)
Transformed Wave spectra	0.6 ft (0.2m)	80%
Motions based on Measured Wave Data	20% over value	34%

The primary objective of calculating the uncertainties is to provide a measure of risk of the vessel touching the various project depths that are being considered. Risk, in this context as explained in Dalzell [6, 7], is defined as that proportion of all possible transits under statistically constant conditions in which the minimum channel clearance would be negative. Under this definition, it is necessary to compute the probability density of the net effective clearance and determine the area up to the net effective clearance of zero. The net effective clearance, therefore, is defined as the difference between the random variables that make up the effective channel depth and the effective vertical displacement of the ship as defined earlier. These random variables are a function of the uncertainty, variability, and bias in each of the major parameters that make up the net effective clearance.

Using the above definition, a risk analysis was performed to determine the probability of any one of the critical parts of the deep draft vessel touching the channel bottom. The critical locations on the vessel usually are the bow at the baseline, the rudder(s), and the port and starboard bilges at the baseline amidships. The risk analysis is performed for each of the wave conditions in a wave climatology that is compiled for the port. The wave condition is defined by the significant wave height, the peak or modal period, and the primary direction. The result of the risk analysis provides a probability of the vessel touching the channel bottom under each of the wave conditions for a

specified project depth. It is assumed that if the risk is greater than some threshold value (normally 1 in 100), then the channel is inaccessible by the deep draft vessel. The days of accessibility of the channel is calculated by determining the persistence of the wave condition that produces the risk of 1 in 100 or greater. The risk calculation is performed for each wave condition and a range of project depths. When complete, the optimum channel depth is the one with the greatest number of days of accessibility per year and which requires the least amount of dredging.

CADET CHANNEL DESIGN TOOL

SYSTEM REQUIREMENTS

The software has been developed for use on the Microsoft Windows NT/2000/XP operating system family. While it is theoretically possible to run the software under Windows 95, 98, or ME, those configurations have not been tested and are not supported. An Intel Pentium 3 or greater and a minimum of 256MB are recommended. While most tasks and operations in CADET can be performed using only the keyboard, there are some which require the use of a mouse. Nearly any printer supported by Windows can be used to print hard copies of results and reports of ship and project configurations.

Installing CADET, its supporting programs and libraries, and the initial sample data files requires approximately 125MB of free disk space. The majority of this space is occupied by the sample data files, so the user of CADET should expect that they will need at least an additional several hundred megabytes free for production use.

INSTALLATION

The software may be installed into any directory on any disk drive that the user chooses. The program executable, C++ runtime DLLs, and the help file should all be placed into the same location. Installing the software only involves copying the contents of the application directory from the distribution media into a location of the user's choosing. Alternatively, a setup program is provided. Using the setup program is the recommended installation method as it automatically creates a program menu folder with shortcuts to the application, help file, and uninstall program. The distribution media will also contain a README.TXT file that documents last minute changes and a listing of the files installed.

STRUCTURE AND ORGANIZATION

The CADET program acts as an interface to four separate programs that perform the necessary calculations for ship motions, underkeel clearance, risk of touching, and accessibility. To provide this capability, CADET maintains several related databases. These databases are divided along three lines; ship geometry and motion transfer functions, project specification (including channel geometry and wave descriptions), and analysis results. The ship information database specifies a link (reference) to a ship geometry description file which defines the hull surface up to the deck at edge. A single ship is also defined by multiple loading conditions, specified as either a draft and trim angle or the drafts at the ends of the ship. Each loading condition is associated with other information such as the metacentric height (GM), roll damping coefficient, water depths of interest, and the speed dependent, shallow water-

induced sinkage and trim. Sinkage and trim at speed (or squat) is specified as a link to an external data file. This file is created using full-scale or model test data, or from an analytical method. The ship database also manages the links to the motion transfer function files created for the water depths of interest for the ship and loading condition(s).

In the context of CADET, a project represents a collection of channel reaches, the wave spectra associated with each reach, and the candidate water depths for each reach. The project database also maintains links to the ships and loading conditions (from the ship database) that are pertinent for the location and channel reaches in question. Therefore, the ship databases must be populated and the transfer functions generated prior to establishing these reference links in the project database.

The results from an analysis are related directly to a specific project and the project database maintains a list of references to each set of results. However, once created, the results are independent of the associated project and the ships and loading conditions used. The database generated for each analysis contains the complete set of information used to produce the results along with references to the files produced (containing the results). For each reach, water depth, and ship/loading condition, the analysis calculates (and saves to files) for inbound and outbound transits, the vertical displacement and velocity variance for each of the control points on each ship, the underkeel clearances and motions allowances for all control points, risk of bottom touching for the limiting control points, and the accessibility (days per year) of each channel reach.

The database files used and maintained by CADET are kept in Extensible Markup Language (XML) format files. XML is an ASCII text format that structures data in a hierarchical manner. XML files can be easily displayed using a web browser or through an XML editor. The other files used by CADET are generally ASCII format, structured appropriately for use by (or generated by) one the CADET component programs.

OPERATION

The CADET program acts as an interface to the analysis programs, a database management system, and a results visualization tool. The databases are structured to support multiple ship hull geometries, each possibly having multiple loading conditions of interest, and multiple channel design projects each with one or more channel reaches. Furthermore, each channel reach has an associated set of wave spectra data files, range of candidate water depths, and associated ship motion transfer function files. The transfer functions are specified for ships and loading conditions in the database.

Once the CADET software is installed, it may be started by double-clicking on the CADET icon located on the desktop or in the CADET program group under the Start menu. CADET will display an initial splash screen showing the program version, and then the main program screen as shown in Figure 2.

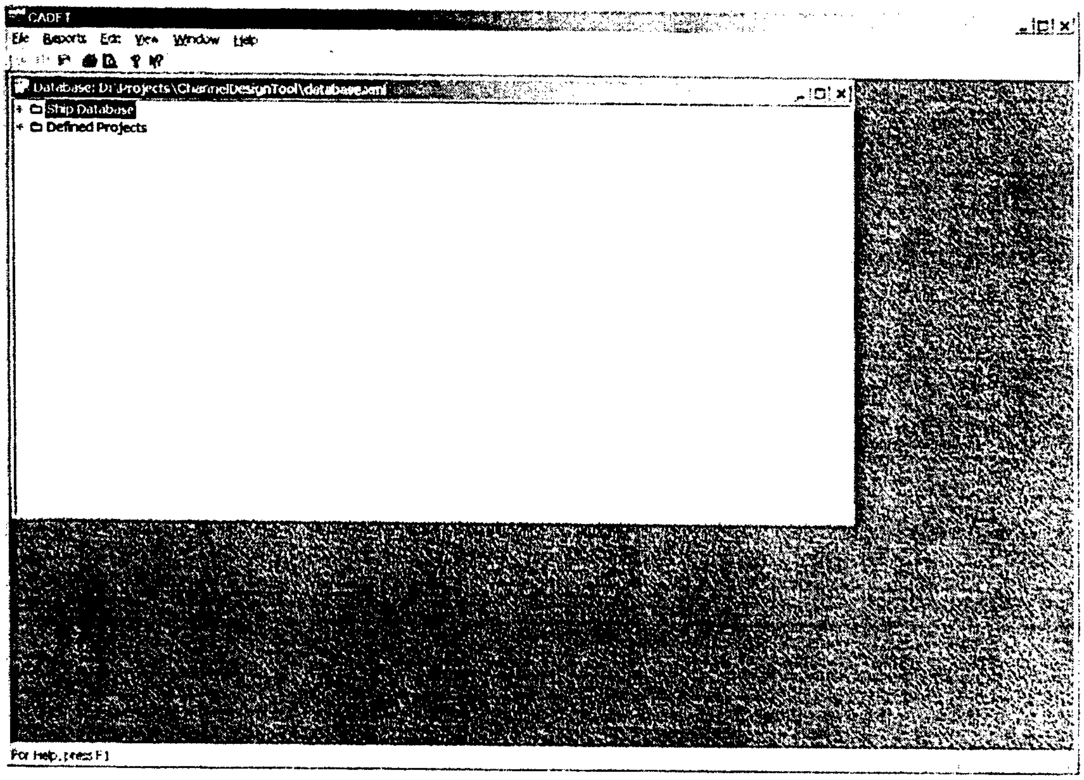


Figure 2. CADET Main Program Screen

This shows the two main sections of the active database, Ship Database and Defined Projects. The sections may be expanded by clicking on the expansion symbol located to the left of the folder icon. The ship database is where the information defining ship geometry, loading conditions, underway squat, ship motions, and critical point locations is defined and contained. The defined projects section is where different channel analysis projects are defined. To add a new ship or project to the database, either right click with the mouse on a section heading or select a section heading and press the F2 function key, then select from the popup context menu "New Ship" or "New Project".

SHIP DATABASE

To add a new ship to the main database, either right-click on the "Ship Database" heading or select the heading name and press the F2 function key, then select "New Ship" from the popup menu. A dialog box will appear as shown in Figure 3. When a ship name is entered, the name is appended to the directory location as the name is typed. The directory specified is by default a path relative to the main database file, however, a full path name may be entered if desired. The ship type can also be entered or selected from the drop down list. The ship length, beam, and depth are entered in feet. The depth of the ship is the vertical distance from the baseline (keel) to the deck at edge.

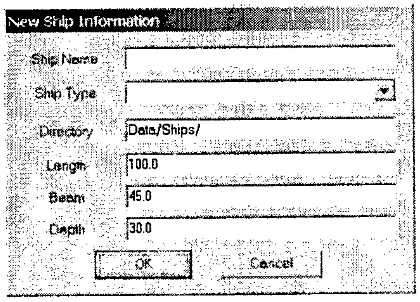


Figure 3. Add New Ship Dialog Box

Once the basic ship data are entered and "OK" is selected, the entry is made in the main database, the directory specified is created, a ship information database file is created in that directory, and a default ship geometry data file is created, also in that directory. A new ship entry will also be added to the main ship database tree shown in Figure 2. The properties for a ship listed in the main ship database tree may be edited by right-clicking on the tree item or selecting the tree item and pressing the F2 function key and selecting "Properties" from the popup menu. The properties that can be changed are the ship name and type.

To remove a ship from the database, either right-click on the ship tree item or selected it and press the F2 function key, and select "Delete" from the popup menu. The user must first confirm the action and is given the choice of deleting all the ship data files or retaining them and just removing the ship entry from the main database. If the ship data directory is empty and the user has not created any additional data files in the ship directory, the directory is removed when the ship is removed from the main database.

Double clicking on a ship tree item in the main database window, or selecting a ship, right-clicking and selecting "Edit" from the popup menu, brings up the ship record window shown in Figure 4. The data in the ship record window are obtained from the ship record database file which lists the loading conditions for the ship. The wireframe representation shown on the right side of the window is obtained from the ship geometry file. Notice that when a ship record is open, the icon for the corresponding tree item in the main database window changes color to indicate that the ship is open. If the user attempts to select an already open ship record, the window for that ship record is brought to the front of the main window and made active. This prevents multiple windows being used to edit a single ship record.

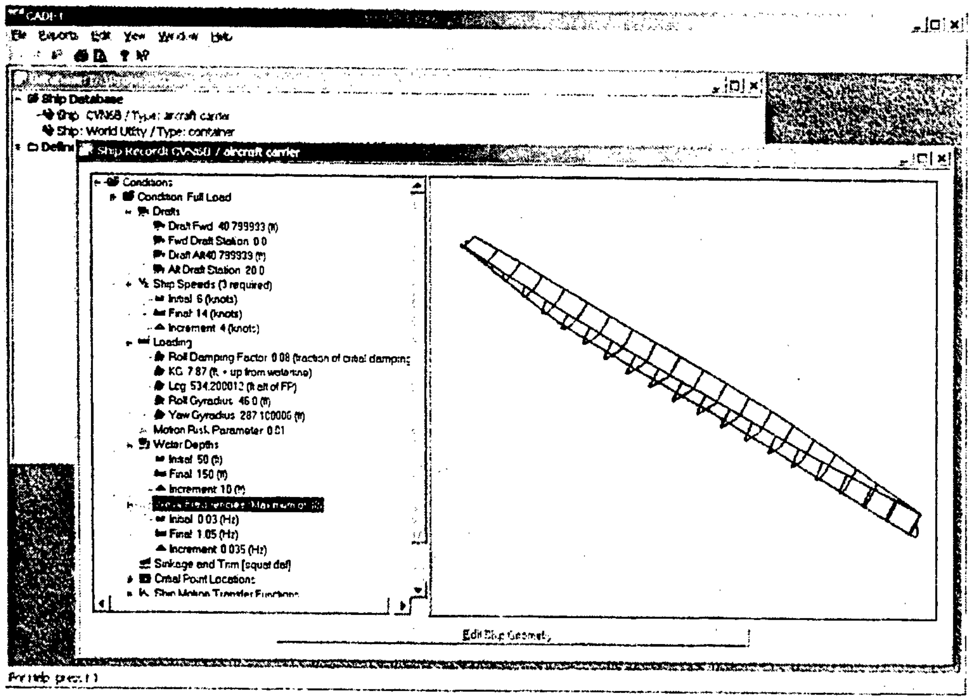


Figure 4. Ship Record Data Window

The hull wireframe image may be manipulated by right-clicking on the image and selecting a desired action from the popup menu. These actions include normal, zoom, rotate, spin, pan, reset, and an options submenu. Descriptions of these menu items are given in Table 2 along with any resulting mouse action behaviors.

Table 2. Ship Geometry Viewing Properties Menu Items

Menu Item Name	Description	Mouse Behavior
Normal	Make the model view static (default)	None
Zoom	Zoom the model view in and out	With the mouse pointer in the view, right-click and hold the mouse button down while moving the mouse up to zoom in and down to zoom out
Rotate	Rotate the model in the plane of the view	With the mouse pointer in the view, right-click and hold the mouse button down while moving the mouse to rotate the model in the plane of the view
Spin	Rotate the model in 3d space	With the mouse pointer in the view, right-click and hold the mouse button down while moving the mouse up and down to rotate along the horizontal axis of the view and left and right to rotate along the vertical axis of the view
Pan	Pan the view of the model	With the mouse pointer in the view, right-click and hold the mouse button down while moving the mouse to pan model in the view
Reset	Reset the view to the original display and set Normal mode	None
Options – Mouse Pull Interaction	Makes the current viewing action (zoom, rotate, spin, pan) respond to the mouse as it is moved (default)	Viewing motion responds to mouse movement
Options – Automatic Interaction	Makes the current viewing action (rotate, spin) respond to the mouse location of the mouse – zoom and pan do not function while in Automatic Interaction mode	Viewing motion response to mouse position in the view
Options – Perspective	Enables perspective viewing (default)	None
Options – Orthographic	Enables orthographic viewing	None

Ship Geometry

When a ship is first created, it is given a default ship geometry data file. The user may edit this file within CADET or physically replace it outside of CADET with another prepared geometry file. To edit the geometry, select the "Edit Ship Geometry" button at the bottom of the window shown in Figure 4. The ship record geometry window will be displayed as shown in Figure 5.

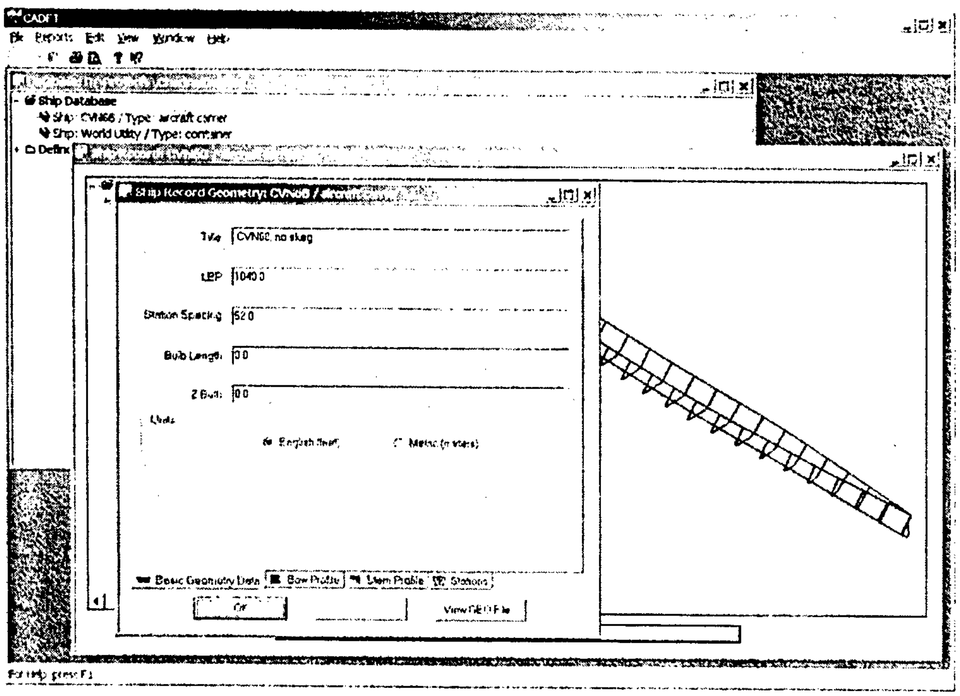


Figure 5. Ship Geometry Edit Window

The ship record geometry window has four tabs across the bottom of the bottom of the window. The "Basic Geometry Data" tab lists the ship title (contained in the geometry file, not from the ship record in the main database), ship length, station spacing, bulb length and location, and the units used for the ship geometry. Note that CADET assumes english units internally so the data for the ship geometry should be converted to english units from metric prior to performing ship motions calculations. When the units are changed, the user is asked to confirm the conversion and given the choice of retaining the geometry data values (and just changing the units flag) or actually converting all geometry values.

The tabs for "Bow Profile", "Stern Profile", and "Stations" allow the user to view the hull form defining curves. Editing data for each of these is similar. The "Stations" tab is shown in Figure 6. At the bottom of the window is a profile view of the ship with the current station (or profile curve) highlighted. On the upper right side is a view of the station (or profile curve) with the defining data points and connecting lines shown. The check boxes below the station view can be used to turn on and off the points and/or connecting lines. On the upper left side is a data grid listing the data point values and point types. Definitions of the point types and the entire ship geometry data

file format is given in Appendix A. The first and last point data types are fixed and can not be changed and at least two data points must be given to define a curve.

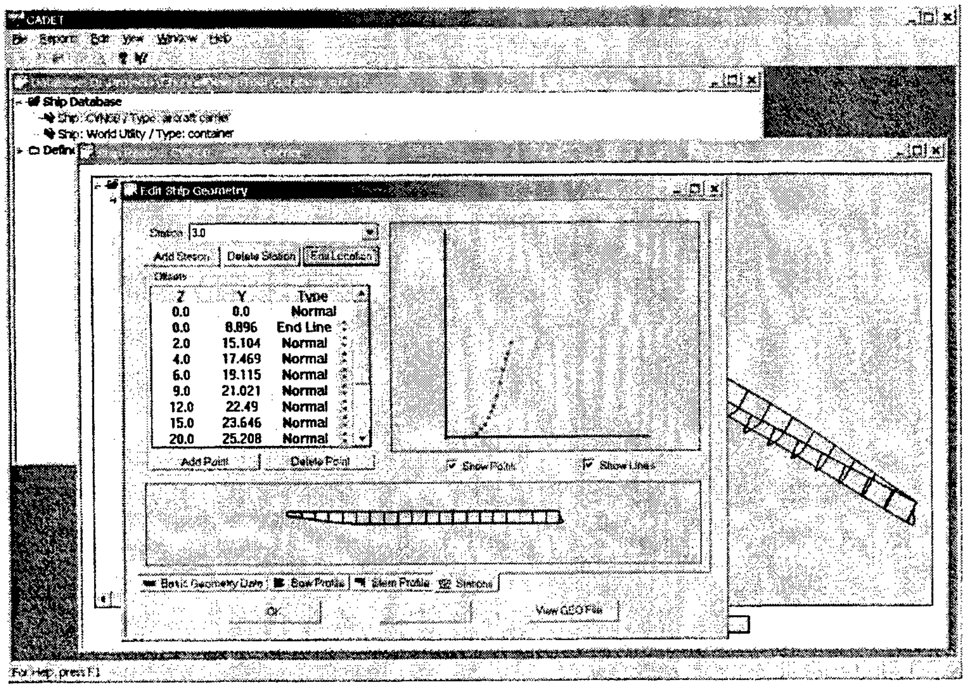


Figure 6. Ship Station Geometry Editing Window

If any changes are made to the ship geometry data, both the "OK" and "Cancel" buttons at the bottom of the window are active. Pressing "OK" will cause the ship geometry data file to be updated with changes while pressing "Cancel" will close the ship geometry data window without saving any changes. The "View GEO File…" button will open a file viewing window that lists the contents of the ship geometry data file (non-editable and without any unsaved changes).

Ship Conditions

A ship condition corresponds to a particular loading condition with specific properties such as roll damping, inertial characteristics, center of gravity, and sinkage and trim as a function of speed. Multiple conditions for a single ship are necessary to allow for light ship and full load conditions to be used for inbound and outbound transits. Ship motions, in the form of transfer functions, are calculated at various nominal water depths for each condition.

To add a new condition to the ship record, either right-click on the "Conditions" label of the root tree item of select the "Conditions" root item and press the F2 function key, and select "New Condition" from the popup menu. A dialog box will be shown as in Figure 7, asking for a condition name and a directory location name. When a condition name is entered, the name is appended to the directory location as the name is typed. The directory specified is by default, a path relative to the directory containing the ship record database file. However, a full (absolute) path name may be entered if desired. It is recommended that only relative paths be used though.

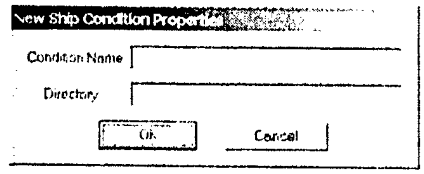


Figure 7. New Ship Condition Properties Dialog Box

Each ship condition in a ship record database has a corresponding tree item in the ship record data window shown in Figure 4. The tree items are expanded and contracted by clicking on the expansion icon on the far left side of the tree item or by using the "+" and "-" keypad keys when the item is selected. To remove a condition, right-click on the condition name tree item and select the "Delete Condition" from the popup menu. The user must confirm the deletion and notice that here, the F2 function key will not display the tree item context menu. If the F2 key is pressed or the tree item is single-clicked, the name of the condition is editable, inline in the tree control. The name can also be edited from a dialog box by selecting the "Properties" popup context menu.

Sub-items to the condition name tree item are used to define the data that is particular to the ship and loading condition. Most (but not all) of these sub-items are used as part of the ship motions calculations associated with the ship loading condition. They include "Drafts" or "Trim" (depending on which is used to define the loading condition), "Ship Speeds", "Loading", "Motion Risk Parameter", "Water Depths", "Wave Frequencies", "Sinkage and Trim", "Critical Point Locations", and "Ship Motion Transfer Functions". Many of the loading condition sub-items also have their own sub-items, all of which are defined in Table 3. For those items that represent a numeric value, the values are edited inline by either single clicking on the item or selecting the item and pressing F2. The edit control used for numeric values allows only numeric data to be entered and rejects alphabetic data or special characters (except '+', '-', and the exponential indicator 'E').

Table 3. Ship Condition Tree Item Definitions

Item Name		Description
Drafts	Draft Fwd	Ship draft in feet at the specified forward location
	Fwd Draft Station	Longitudinal location in stations of the forward ship draft reading
	Draft Aft	Ship draft in feet at the specified aft location
	Aft Draft Station	Longitudinal location in stations of the aft ship draft reading
Trim	Trim Angle	Degrees, positive bow up
	Draft	Ship draft in feet at the specified location
	Draft Location	Longitudinal location in stations of the ship draft reading
Ship Speeds	Initial	Beginning ship speed in knots
	Final	Final ship speed in knots
	Increment	Ship speed increment in knots
Loading	Roll damping factor	The roll damping coefficient expressed as a fraction of critical damping
	KG	Vertical center of gravity in feet relative to the baseline
	Lcg	Longitudinal center of gravity in feet aft of the forward perpendicular
	Roll Gyradius	Roll mass radius of gyration in feet
	Yaw Gyradius	Yaw mass radius of gyration in feet

Table 3 (Continued). Ship Condition Tree Item Definitions

Item Name				Description
Motion Risk Parameter				Risk parameter (see Equation1)
Water Depth	Initial			Beginning water depth in feet
	Final			Final water depth in feet
	Increment			Water depth increment in feet
Wave Frequencies	Initial			Beginning wave frequency in Hz
	Final			Final wave frequency in Hz
	Increment			Wave frequency increment in Hz
Sinkage and Trim				Sinkage and trim data file name and location
Critical Point Locations	Primary Points	Point Bow	X	Longitudinal position of the point in stations
			Y	Transverse position of the point in feet positive to port
			Z	Vertical position of the point in feet above the baseline
		Point Port Rudder	X	Longitudinal position of the point in stations
			Y	Transverse position of the point in feet positive to port
			Z	Vertical position of the point in feet above the baseline
		Point Strb Rudder	X	Longitudinal position of the point in stations
			Y	Transverse position of the point in feet positive to port
			Z	Vertical position of the point in feet above the baseline

Table 3 (Continued). Ship Condition Tree Item Definitions

Item Name				Description
Critical Point Locations	Primary Points	Point Port Bilge	X	Longitudinal position of the point in stations
			Y	Transverse position of the point in feet positive to port
			Z	Vertical position of the point in feet above the baseline
		Point Strb Bilge	X	Longitudinal position of the point in stations
			Y	Transverse position of the point in feet positive to port
			Z	Vertical position of the point in feet above the baseline
	Alternate Points	Point 1…4	X	Longitudinal position of the point in stations
			Y	Transverse position of the point in feet positive to port
			Z	Vertical position of the point in feet above the baseline
Ship Motion Transfer Functions	For depth=<…>			Represents a ship motion transfer function for a particular water depth

When a ship condition is first created, the loading is initially undefined. A tree item labeled "[Draft/Trim Undefined – dbl click to select]" is shown. The user must double-click the item to select either forward and aft drafts or a draft and trim angle, to define the loading condition. This selection must be made prior to any ship motion calculations being performed.

Sinkage and trim data for a loading condition are defined in an external data file and referenced in the ship record database. The format for the data file is fully explained in Appendix A. Initially, there is no file defined and the tree item for sinkage and trim is labeled as such. The tree item popup context menu initially has one selection, "Import Sinkage and Trim Data File". This menu item will open a data file selection window as shown in Figure 8. Once a sinkage and trim data file has been selected, three additional context menu items are available, "View Sinkage and Trim Data", "Plot Sinkage and Trim Data", and "Remove Definition". These allow the data file contents to be viewed (not edited) or plotted in a window and for the file association to be removed (returning to the initial state).

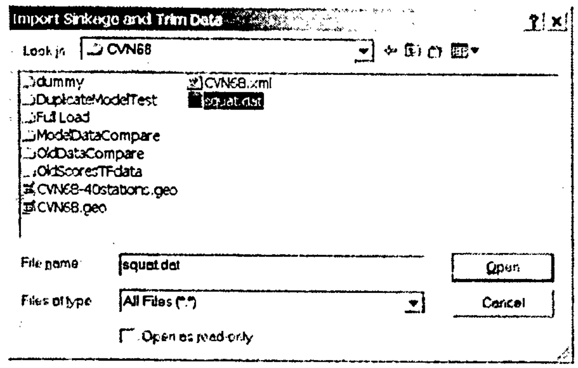


Figure 8. Sinkage and Trim Data File Open Window

Critical points on the ship hull include five primary points and up to four alternate points. An allowance is made to define, for each of these two point groups, a minimum required bottom offset. The offset defines a minimum vertical clearance allowed between the point and the channel bottom. For example, the bottom of the propeller disk must be no less then 1 ft above the channel bottom. The offset for the primary or alternate point groups is changed by selecting the group tree item and pressing the F2 function key. The five primary critical points are usually used to locate the lowest point at the bow, two (normally symmetric) bilge points, and two stern points (normally symmetric, at the low points of the rudders). Zero to four alternate point locations can also be defined at any additional locations desired. All critical points are given in cartesian coordinates relative to the origin at the forward perpendicular, centerline, and the baseline. The text label for a critical point can be edited inline by single-clicking on the point label tree item. To add an alternate point, right-click on the "Alternate Points" item and select "New Point" from the popup context menu. To remove an alternate point, right-click on the point label and select "Delete Point" from the popup context menu.

Ship Motion Transfer Functions

Ship motion transfer functions are associated with a ship loading condition and there is one transfer function for each water depth defined for a loading condition. The computer program SCORES is used to calculate the shallow water transfer functions for a range of speeds, wave frequencies, and ship headings (15 degree increments used) [10, 11]. SCORES is a commercial frequency domain, strip theory based seakeeping program developed by Dr. Paul Kaplan, and NSWCCD has obtained a license to distribute SCORES with CADET. The operation of SCORES is performed by CADET by first generating a hull form description from the geometry data file using a GEO2SCORES conversion program*. Operation of GEO2SCORES is transparent to the user of CADET. The SCORES input file created by the GEO2SCORES converter is modified by CADET to reflect the data for the ship loading condition and the water depth is modified. The SCORES input file can then be used by SCORES to produce the transfer function output file. The transfer functions for each speed and heading are contained in the text output file from SCORES, which are extracted and compressed into a binary format file by another conversion program,

* Dalzell, J.F., "Note on Ship Geometry Utilities", unpublished notes, April 1997.

COMPRESSXFER. The SCORES input and output files and the compressed binary transfer function files are located in the directory specified and created for the loading condition.

When the GEO2SCORES conversion program is executed by CADET, it does so in a separate DOS window, as shown in Figure 9. However, SCORES and COMPRESSXFER both are executed in a background thread with the output from those programs directed to a window within CADET, as shown in Figure 10. These three programs are executed in the following order; GEO2SCORES for all specified water depths, then SCORES and COMPRESSXFER in turn for each water depth.

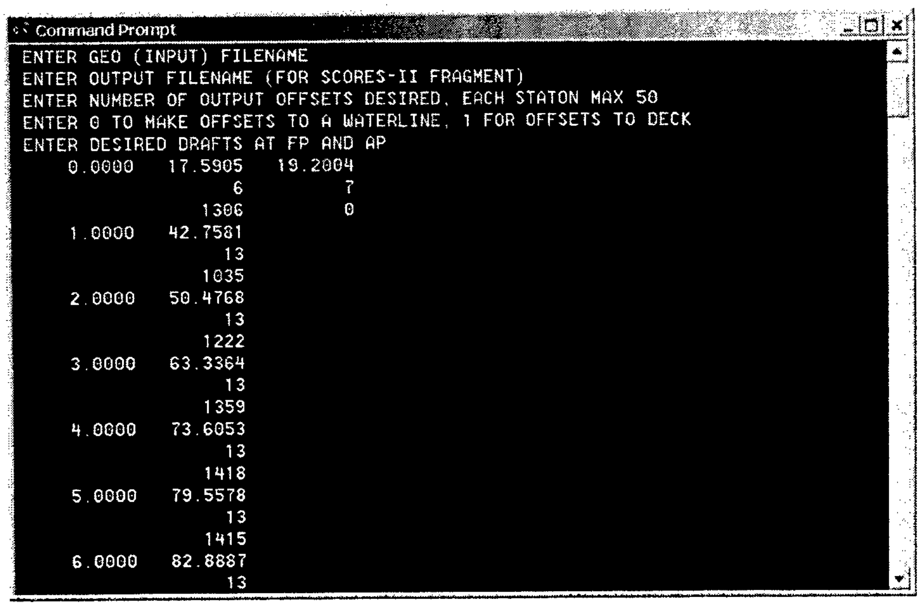


Figure 9. GEO2SCORES Conversion Program Window

It is possible that things could go wrong when an external program such as SCORES is run from within CADET. Inconsistent input data could throw off the creation of SCORES input from the ship geometry data file, the center of gravity could be located such that the ship is unstable in roll (negative metacentric height), and numerous other possibilities exists. If any of the programs (GEO2SCORES, SCORES, COMPRESSXFER) fails to process their input data and produce expected results, the transfer functions needed by CADET will not be generated. CADET will attempt to recognize such a condition and flag the effected transfer function entries appropriately. However, the user is ultimately responsible for determining the exact nature of the problem and remedying the situation. The output listed in the SCORES and COMPRESSXFER program output window is a good place to start looking when problems do arise. If SCORES could not find the specified input file, then there is possibly something wrong with the geometry description file, since GEO2SCORES could not process it. If COMPRESSXFER could not read the complete SCORES output file, then there is possibly a problem with the input given to SCORES and the output could not be fully generated. The idea is to find where the first sign of trouble is and work backward from there.

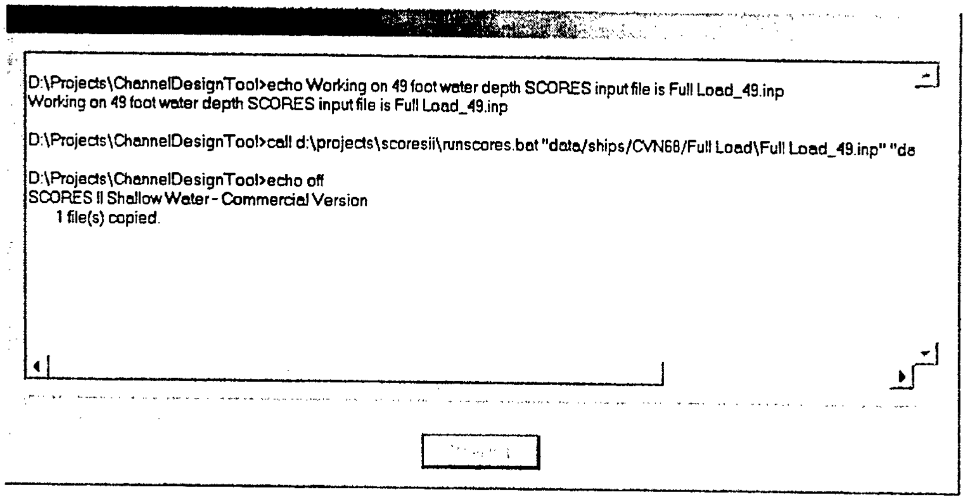


Figure 10. SCORES and COMPRESSXFER Program Output Window

The "Ship Motion Transfer Function" tree item has five popup context menu items, "Generate", "Generate and Run", "Rerun", "Remove Current Depths", and "Remove All". If no transfer functions or SCORES input files have been created, the last two items are not active. Selecting "Generate" will force new SCORES input files to be created using the current loading condition information. Selecting "Generate and Run" will force new SCORES input files to be created using the current loading condition information and SCORES to be executed using each of those input files. Following each execution of SCORES, the COMPRESSXFER program is executing using the SCORES output file. Each transfer function has an associated tree item entry with the water depth and ship speeds noted. Each transfer function tree item also indicates the status of the transfer functions. Several states are possible for a transfer function item and are indicated visually by a state icon. The icons and descriptions of these states are summarized in Table 4.

Table 4. Transfer Function Tree Item States and Indicators

Status Icon	Description	Possible States	Description
	Ship geometry and loading condition information used for motions calculations is consistent with current configuration	Not run – ready	Transfer function file has not been generated
		blank	Transfer function has been generated
	Ship loading condition(s) have changed since last time SCORES input file generated	Not run – loading changed	Transfer function file has not been generated
		Loading Changed	Transfer function has been generated
	Ship hull geometry has changed since last time SCORES input file generated	Not run – geometry changed	Transfer function file has not been generated
		Geometry changed	Transfer function has been generated

Transfer function tree items have five popup context menu items, "XferFn Explorer", "View SCORES Input File", "ReGenerate SCORES Input File", "Run SCORES", and "Delete". The function of each should be self explanatory, with the exception of the first. The "XferFn Explorer" is used to view graphical and tabular representations of the transfer function data in the compressed binary file. Figure 11 shows the transfer function explorer window. The title bar of the window indicates the water depth, ship name, and condition name.

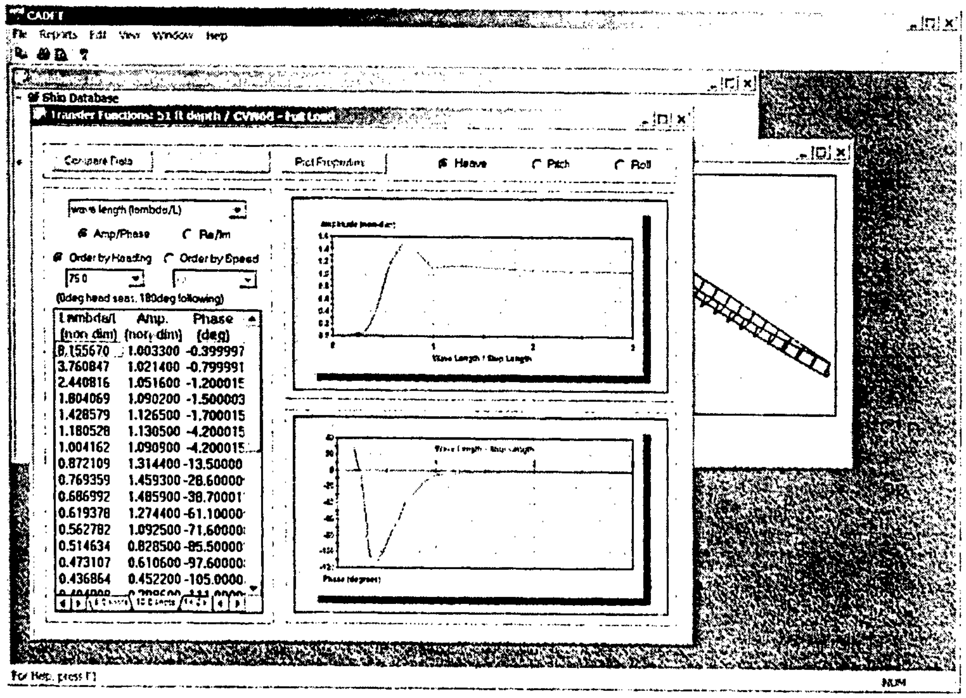


Figure 11. Ship Motion Transfer Function Explorer Window

The transfer functions for heave, roll, and pitch can be viewed in a variety of formats including amplitude and phase, and real and imaginary parts, and by either wave frequency in hertz, encounter frequency in hertz, or wave length to ship length ratio. The data grid lists the numeric values of the selected transfer function, in the format specified, for single values of heading angle and ship speed. If the data grid is ordered by heading, the tabs along the bottom of the grid indicate ship speed. If ordered by speed, the tabs indicate heading. The drop-down list boxes that are below the order selection radio buttons are used to select a specific ordering value. The plots on the right side of the window (as well as the data grid) are updated each time a change is made, so that the plots always reflect the data values in the grid.

It is often useful to compare the transfer functions computed by SCORES and those obtained from other sources such as model tests, for example. The three buttons in the upper left corner are used to specify a data file to use or to remove the comparison data from the plots and to adjust the plot axis ranges. The format of the data file is given in Appendix A. When comparison data are used, it appears in the plots as a black cross for each of the points.

The assumed convention for transfer function data files used by CADET is that head seas is zero degrees, 90 degrees starboard beam seas, and 180 degrees for following seas. This differs from the convention assumed by SCORES which has 180 degrees for head seas. The COMPRESSXFER program performs the transformation automatically and also adjusts for the SCORES definitions of the heave and pitch phase (which are off by 180 degrees). There are also conversions made to the pitch and roll amplitudes so that they are expressed in terms of radians.

PROJECT DATABASE

To add a new project to the main database, from the main database window, either right-click on the "Defined Projects" heading or select the heading name and press the F2 function key, then select "New Project" from the popup menu. A dialog box will appear as shown in Figure 12. When a project name is entered, the name is appended to the directory location as the name is typed. The directory specified is by default a path relative to the main database file, however, a full path name may be entered if desired. The location is used only for documentation purposes.

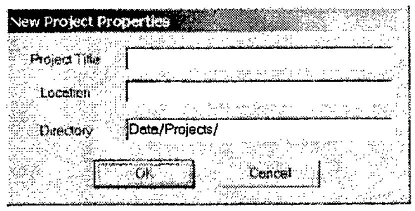


Figure 12. New Project Dialog Box

Once the project name, location, and directory data are entered and "OK" is selected, the entry is made in the main database, the directory specified is created, and a project information database file is created in that directory. A new project entry will also be added to the main ship database tree shown in Figure 2. The properties for a project listed in the main ship database tree may be edited by right-clicking on the tree item, or by selecting the tree item and pressing the F2 function key and selecting "Properties" from the popup menu. The properties that can be changed are the project name and location.

To remove a project from the database, either right-click on the project tree item, or select it and press the F2 function key, and select "Delete" from the popup menu. The user must first confirm the action and is given the choice of deleting all the project data files or retaining them and just removing the project entry from the main database. If the project data directory is empty and the user has not created any additional data files in the project directory, the directory is removed when the project is removed from the main database.

Double clicking on a project tree item in the main database window, or selecting a project, right-clicking and selecting "Edit" from the popup menu, brings up the project configuration window shown in Figure 13. The data in the project configuration window are obtained from the project database file which lists the channel reach geometry, wave environment represented by directional spectra, ships and ship conditions to be used for the project, and textual comments relating to the project. Notice that when a project configuration is open, the icon for the corresponding tree item in the main database window changes color to indicate that the project is open. If the user attempts to select an already open project configuration, the window for that project is brought to the front of the main window and made active. This prevents multiple windows being used to edit a single project configuration.

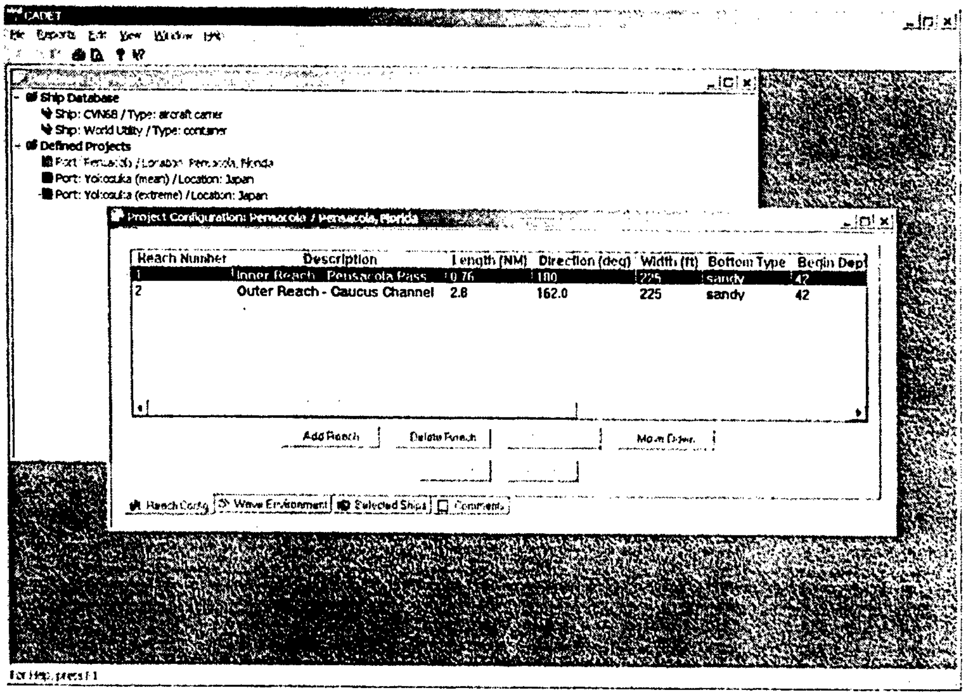


Figure 13. Project Configuration Window

There are four tabs located at the bottom of the project configuration window – "Reach Config", "Wave Environment", "Selected Ships", and "Comments". Selecting a tab by clicking on it will change the contents of the project configuration window to reflect the tab selected.

Channel Reach Configuration

For the purpose of the analysis performed by CADET, a channel reach is defined by its length, direction, range of potential project depths, overdredge amount and variability, and wave coefficient of variability. The other values listed, such as width and bottom type, are used for documentation purposes only. The recommended convention is to order the reaches from the inshore to offshore reaches with reach directions measured relative to North in the outbound direction.

The data and text values given for each reach can all be edited in-place in the grid. If any change is made to the reach configuration, the "Commit" and "Revert" buttons become active. Selecting "Commit" will update the project configuration database while selecting "Revert" will discard any changes made since the previous commit, restoring the display to the previous values.

Wave Environment

The wave environment is defined by directional wave spectra data files referenced by the project configuration database. The wave data files are specific to each channel reach, allowing for CADET to account for changes in waves between inshore and offshore locations. The drop-down list box at the top of the window is used to select a channel reach and the grid below it lists the associated wave spectra data files and information about the data files as shown in Figure 14. This includes the significant wave height, modal period, and dominant wave direction, as

listed in each wave spectra data file. CADET can also compute and display the significant wave height from the spectral data.

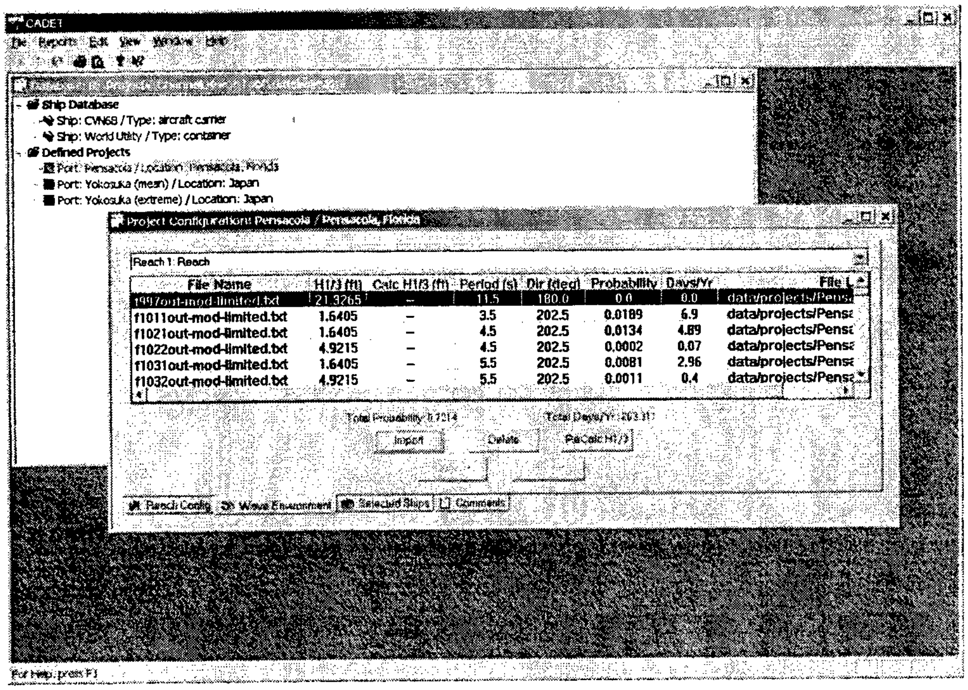


Figure 14. Wave Environment Configuration Window

The probability of occurrence of a wave spectrum is the only field that can be edited (in-line in the grid by clicking on the field). This is used to infer the number of days per year the wave condition occurs. The total number of days per year and total probability are listed below the grid control. The total probability of all waves should equal one, which corresponds to 365 days per year.

A wave data file is imported by pressing the "Import" button, which displays a file selection dialog box similar to that shown in Figure 8. When a wave data file is imported, it is read and the significant wave height is calculated from the spectra. The significant wave height, modal period, and dominant direction documented in the file header are added to the project database for the corresponding reach and a default probability of zero is assigned. Finally, the grid showing the associated data files is updated with the newly imported wave data record.

When the "ReCalc H1/3" button in pressed, the list of all wave data files for the current reach is iterated through. Each of the data files is read and the significant wave height is calculated from the spectra and displayed. If the user double clicks on a row of the grid, the wave data file is read and displayed in a wave spectra data display window, as shown in Figure 15.

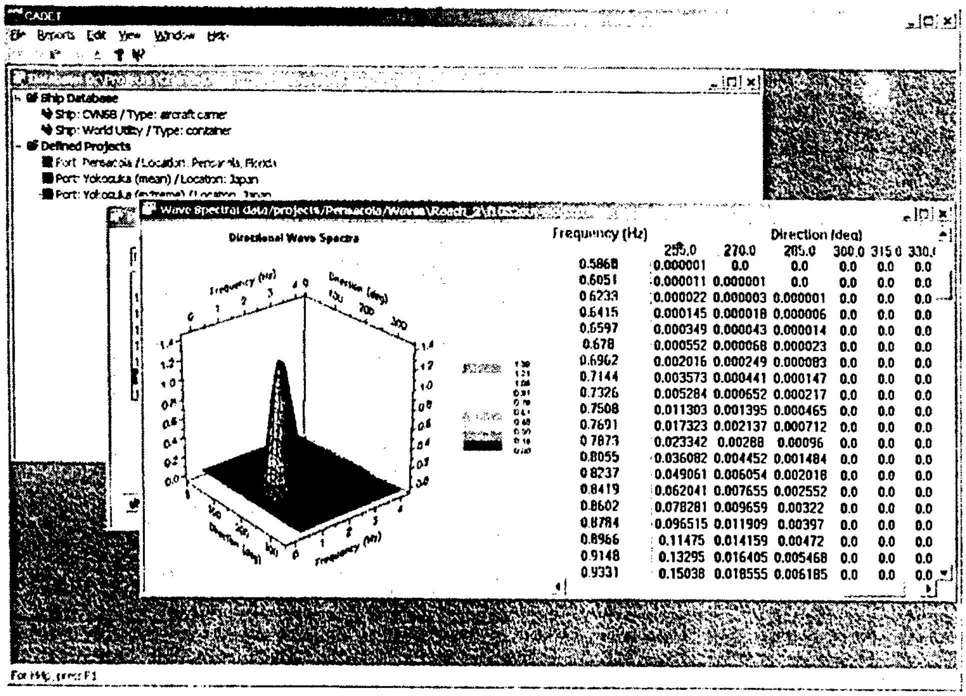


Figure 15. Wave Spectra Data Display Window

The left side the wave spectra data display window shows a 3-dimensional, color contoured plot of the spectral ordinate surface over frequency and direction. The plot may be manipulated using a combination of the mouse and keyboard, according to the shortcuts given in Table 5.

Table 5. Wave Spectra Plot Keyboard/Mouse Shortcuts

Action	Mouse	Keyboard
Rotation	Press and hold the left and right buttons (or center on a 3-button mouse)	To constrain rotation along a particular axis, hold down the "x", "y", "z", or "e" key
Translation	Press and hold the left and right buttons (or center on a 3-button mouse)	Press and hold the SHIFT key
Scale	Press and hold the left and right buttons (or center on a 3-button mouse)	Press and hold the CTRL key
Zoom	Press and hold the left button	*no action*
Reset	*no action*	Press the "r" key to rest all scaling, translation, and zooming, rotation is not reset

Selected Ship Conditions

CADET has the ability to process multiple ships and ship loading conditions for a project configuration when an analysis is performed. The ship and loading condition selection window is shown in Figure 16. All of the loading conditions for each ship are shown in a tree structure with selection check boxes. If a selection box for a ship is checked, all of the loading conditions for the ship are automatically selected. If only some of the loading conditions for a ship are selected, the ship selection box is checked and shown with a gray background color. Changes made must be committed to the project database or reverted to the previously committed changes.

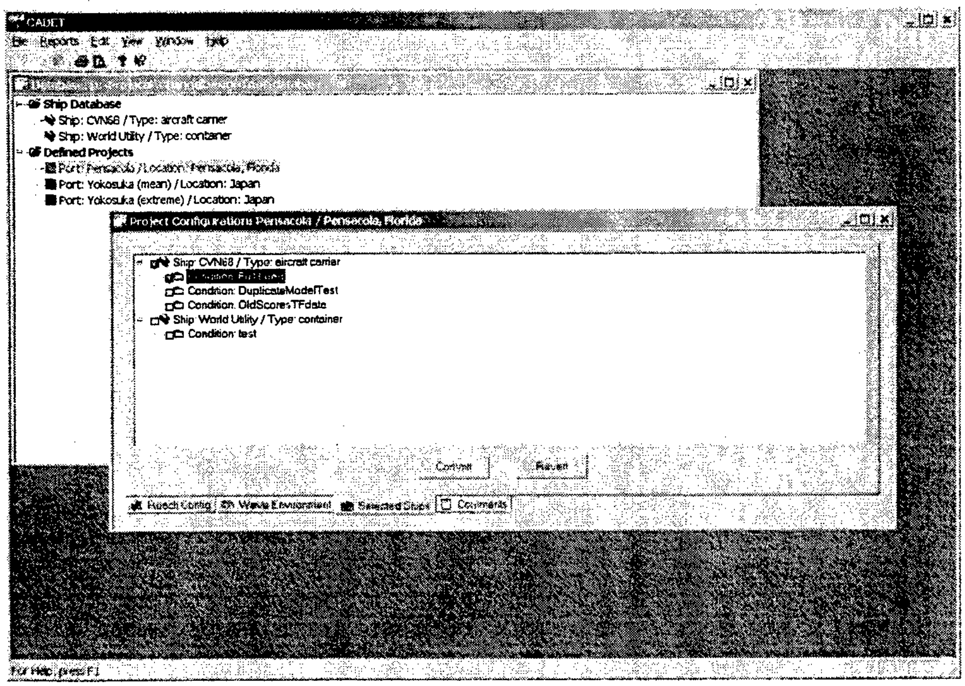


Figure 16. Ship and Loading Condition Selection Window

The user of CADET is responsible for ensuring that the transfer functions for the ships and loading conditions selected exist, for the water depths specified for all project channel reaches, prior to a project analysis being performed. In order to establish a new link to a ship and loading condition, the ship must exist in the main database and the loading condition must exist in the corresponding ship database.

Comments

The project configuration comment window is where textual annotations and descriptions are entered, as shown in Figure 17.

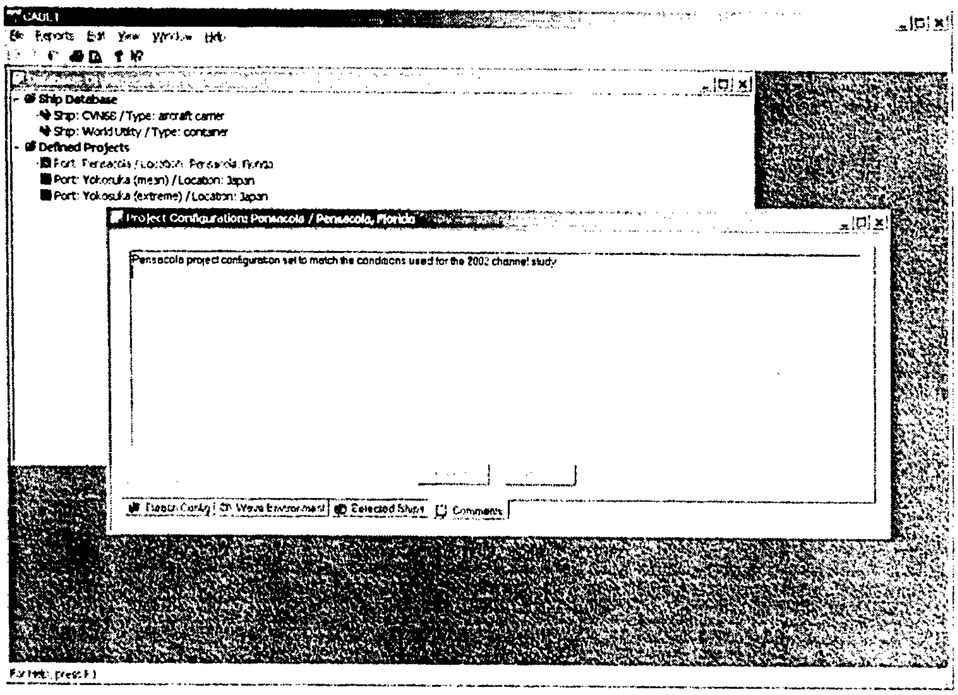


Figure 17. Project Configuration Comment Window

CHANNEL ANALYSIS

The analysis of a project database produces the underkeel clearances for the ship conditions selected and project reach geometry, wave conditions, and water depths. The analysis includes a risk analysis which yields the probability of bottom touching. Accessibility of the channel reaches, expressed as days per year accessible, is also calculated taking into account the probability of occurrence of the wave spectra data used when computing underkeel clearance. Three separate external programs are utilized by CADET to perform the channel analysis calculations; IMOT, RISKANALYSIS, and ACCESS.

CADET allows for multiple sets of results to be maintained, so that different alternative project options may the studied and compared. Each set of results fully documents the configuration of the project at the time the analysis was performed. Printed reports can be generated by CADET and include the documentation for the results set in addition to the underkeel clearances, risk probabilities, and accessibility values.

To perform a channel analysis, view results, print reports, and purge unwanted results, a project configuration window (as shown Figure 13) must be the active window in CADET. Select the "Reports" menu item from the application menu bar, and then select either "Create", "View...", or "Purge". When an analysis is requested, the user is prompted for a directory name where the results will be created, as shown in Figure 18. The directory name should not be an absolute path but should instead be considered as relative to the project database directory.

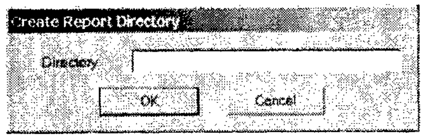


Figure 18. Channel Analysis Output Directory Dialog

Prior to the execution of the analysis programs, CADET performs an internal consistency check – validating the existence of all necessary files to be used and ensuring that the state of the project configuration is correct. If a potentially fatal condition is found to exist, CADET will display an error message dialog box as in Figure 19.

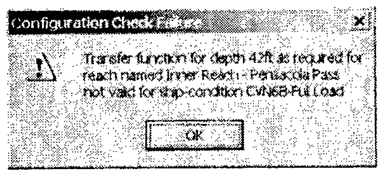


Figure 19. Pre-Analysis Error Message Dialog

Assuming that the project database is in a valid state and that all necessary ship motion transfer function files exist, CADET will set up input files for IMOT and start execution of IMOT, RISKANALYSIS, and ACCESS. When these programs execute, the CADET application window is replaced with an output redirection window as shown in Figure 20. The amount of time necessary to perform a complete analysis can be significant depending on the number of ship conditions selected, water depths, and wave conditions. While the execution progresses, the user could if necessary, force an early termination by pressing the "Abort" button. If pressed, the button label changes to "Aborting…" and further processing is canceled once the currently executing program is finished. The button label will then change to "DONE" and will wait until the button is pressed. The CADET application interface window will then reappear. Note that it may take up to several minutes to abort, depending on where in the run execution process the analysis is and the size of the project database (number of reaches and wave conditions)

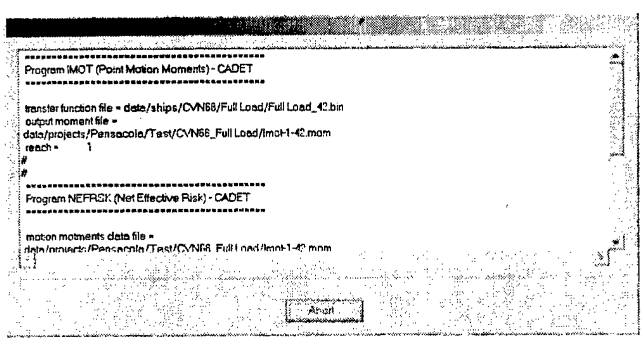


Figure 20. IMOT, RISKANALYSIS, and ACCESS Program Output Window

Channel Analysis Results

The project database maintains a list of multiple sets of analysis results. It should be noted that once created, the analysis results are independent of the project database and all ship databases. To view a results report, a project configuration window (as shown Figure 13) must be the active window in CADET. Select the "Reports"

menu item from the application menu bar, and then select "View". A selection dialog, as shown in Figure 21, will be displayed. Select any one of the listed reports sets and press "OK".

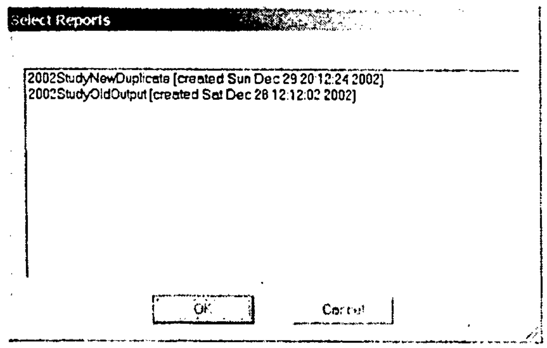


Figure 21. Report Selection Dialog

Once a report has been selected and opened, a results display window will be shown as in Figure 22. By default the initial display will show a plot of channel accessibility. The display is divided into three split windows. The upper right window contains a tree of ships and loading conditions from which to select from, while the lower right window contains a tree listing all of the project reaches. The plot in the left window shows the minimum limiting accessibility considering all of the ship loading conditions in the sub-tree of the selection in the upper right window tree, for the reach selected in the lower right tree. The minimum limiting accessibility also considers all ship speeds and initially by default, both inbound and outbound transits.

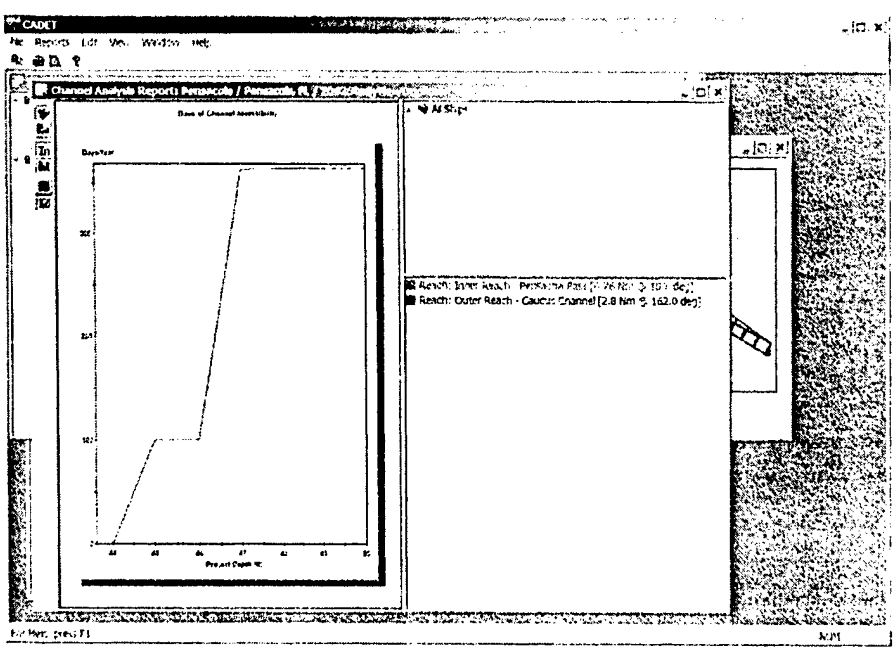


Figure 22. Accessibility Results Graphical Display Window

The plot of accessibility can be manipulated by the user to alter the view. Table 6 lists the functions that can be performed and the keyboard and/or mouse actions needed to perform those functions. The toolbar on the left side

of the plot window shown in Figure 22 can be used to change the data that is displayed and how the data is displayed. Table 7 lists the toolbar icons and provides a description of the function of each.

Table 6. Accessibility Plot Keyboard/Mouse Shortcuts

Action	Mouse	Keyboard
Scale	Press and hold the left and right buttons (or center on a 3-button mouse)	Press and hold the CTRL key
Move	Press and hold the left and right buttons (or center on a 3-button mouse)	Press and hold the SHIFT key
Zoom	Press and hold the left button	Press and hold the CTRL key
Axis Zoom	Press and hold the left button	Press and hold the SHIFT key
Reset	*no action*	Press the "r" key to rest all scaling, translation, and zooming, rotation is not reset

Table 7. Results Display View Toolbar Icons

Toolbar Icon	Description
	Display accessibility
	Display risk probabilities
	Include inbound transits
	Include outbound transits
	Display data in tabular format
	Display data in graphical format

Figure 23 shows the risk analysis results, displayed when the risk toolbar button is depressed. The graphical representation displayed for the risk results is a three-dimensional plot of the point values for three selected independent variables and a dependant variable. The variables are chosen from the four drop-down list boxes at the top of the plot area. The two on top and the lower left drop-down list boxes are used to select the variables to be displayed on the independent axes. The drop-down list box on the lower right is used to select the dependant variable whose point color is chosen based on its value. The legend shown on the plot relates particular ranges of value of the chosen dependant variable with a point type and color. The plot may also be manipulated using the mouse and keyboard according to the shortcuts shown in Table 5.

The two toolbar buttons for inbound and outbound transits are used to filter the data being displayed to either or both directions. The ability to filter the results being displayed is an important capability that is crucial to properly interpreting and utilizing the results provided by CADET. The other display filters are provided by the two tree controls on the right side of the display window. The ship selection tree, on the top, will limit the data to those ships and loading conditions that are highlighted and all that are below the selected tree item in the tree hierarchy. The channel reach selection tree, on the bottom, limits the data to the single reach selected.

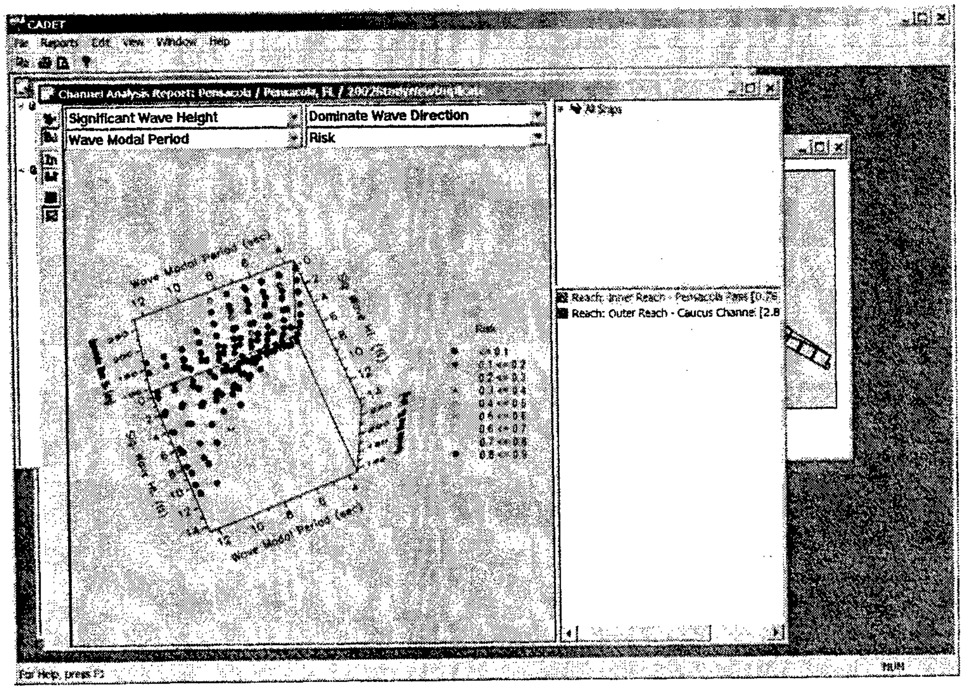
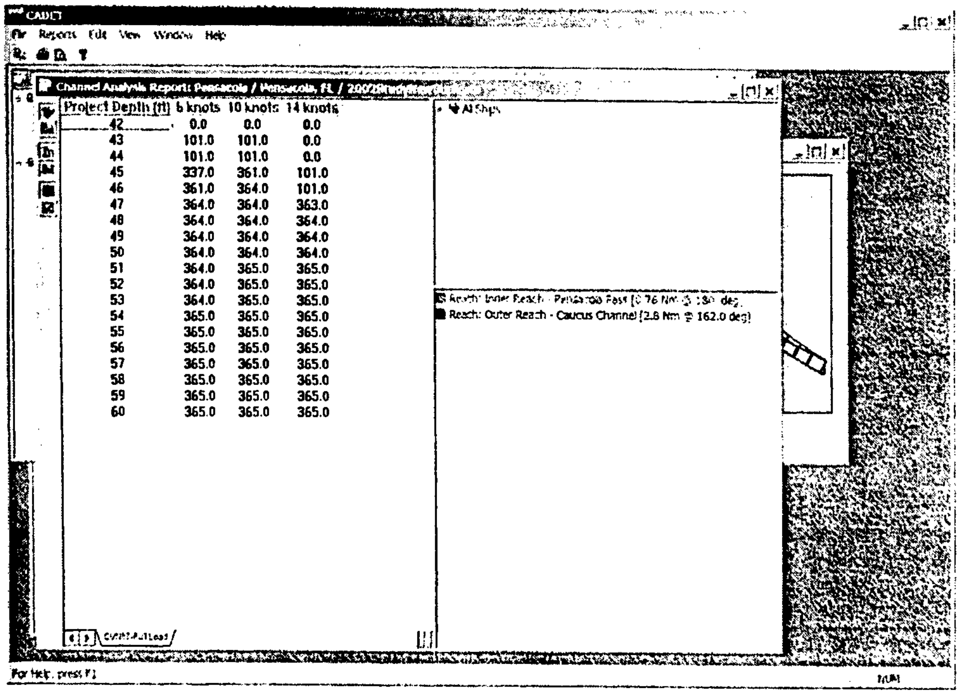


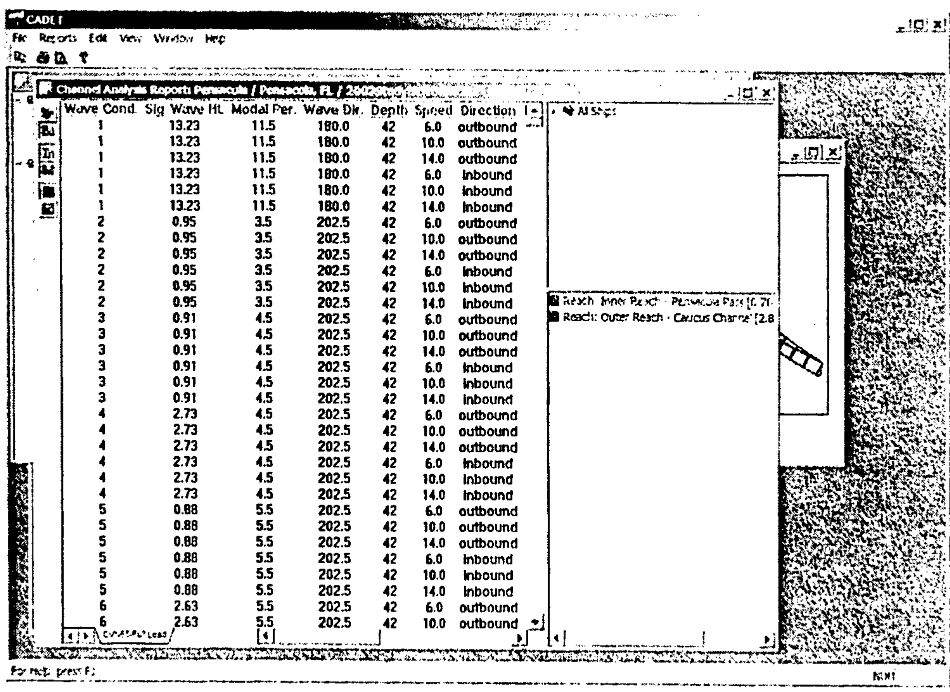
Figure 23. Risk Analysis Results Graphical Display Window

The plot of results may be changed to a tabular, spreadsheet format, displayed by depressing the Tabular Display toolbar button. The breakdown of the data display is more detailed in tabular form than in graphical form, with a spreadsheet tab shown for each ship and loading condition combination. Figures 24 and 25 show the tabular display of channel accessibility and risk, respectively. For accessibility results, the full results for each speed and water depth are shown. When risk results are displayed, the details of the risks and associated clearances are shown for all of the wave conditions.



Project Depth (ft)	6 knots	10 knots	14 knots
42	0.0	0.0	0.0
43	101.0	101.0	0.0
44	101.0	101.0	0.0
45	337.0	361.0	101.0
46	361.0	364.0	101.0
47	364.0	364.0	363.0
48	364.0	364.0	364.0
49	364.0	364.0	364.0
50	364.0	364.0	364.0
51	364.0	365.0	365.0
52	364.0	365.0	365.0
53	364.0	365.0	365.0
54	365.0	365.0	365.0
55	365.0	365.0	365.0
56	365.0	365.0	365.0
57	365.0	365.0	365.0
58	365.0	365.0	365.0
59	365.0	365.0	365.0
60	365.0	365.0	365.0

Figure 24. Accessibility Results Tabular Display Window



Wave Cond	Sig Wave Ht.	Modal Per.	Wave Dir.	Depth	Speed	Direction
1	13.23	11.5	180.0	42	6.0	outbound
1	13.23	11.5	180.0	42	10.0	outbound
1	13.23	11.5	180.0	42	14.0	outbound
1	13.23	11.5	180.0	42	6.0	inbound
1	13.23	11.5	180.0	42	10.0	inbound
1	13.23	11.5	180.0	42	14.0	inbound
2	0.95	3.5	202.5	42	6.0	outbound
2	0.95	3.5	202.5	42	10.0	outbound
2	0.95	3.5	202.5	42	14.0	outbound
2	0.95	3.5	202.5	42	6.0	inbound
2	0.95	3.5	202.5	42	10.0	inbound
2	0.95	3.5	202.5	42	14.0	inbound
3	0.91	4.5	202.5	42	6.0	outbound
3	0.91	4.5	202.5	42	10.0	outbound
3	0.91	4.5	202.5	42	14.0	outbound
3	0.91	4.5	202.5	42	6.0	inbound
3	0.91	4.5	202.5	42	10.0	inbound
3	0.91	4.5	202.5	42	14.0	inbound
4	2.73	4.5	202.5	42	6.0	outbound
4	2.73	4.5	202.5	42	10.0	outbound
4	2.73	4.5	202.5	42	14.0	outbound
4	2.73	4.5	202.5	42	6.0	inbound
4	2.73	4.5	202.5	42	10.0	inbound
4	2.73	4.5	202.5	42	14.0	inbound
5	0.88	5.5	202.5	42	6.0	outbound
5	0.88	5.5	202.5	42	10.0	outbound
5	0.88	5.5	202.5	42	14.0	outbound
5	0.88	5.5	202.5	42	6.0	inbound
5	0.88	5.5	202.5	42	10.0	inbound
5	0.88	5.5	202.5	42	14.0	inbound
6	2.63	5.5	202.5	42	6.0	outbound
6	2.63	5.5	202.5	42	10.0	outbound

Figure 25. Risk Results Tabular Display Window

When a project report is no longer needed, it may be deleted from the project database and the report directory physically deleted. To delete a report, a project configuration window (as shown Figure 13) must be the active window in CADET. Select the "Reports" menu item from the application menu bar, and then select "Delete". A report selection dialog will be displayed, as shown in Figure 26. One or more reports can be selected and deleted by pressing "OK".

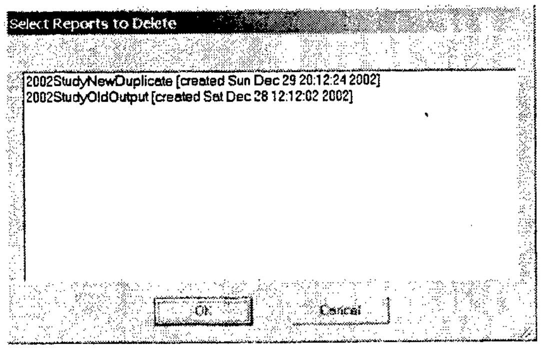


Figure 26. Delete Reports Dialog

PROGRAM MENU AND TOOLBAR

While nearly all of the functionality of CADET is accessed via mouse actions on tree and grid controls displayed within child windows, the application window does contain a menu bar and tool bar that provide general functionality. The main menu contains six popup menu items; File, Reports, Edit, View, Window, and Help. Table 8 lists each of the menu items and sub-items and descriptions of their purpose.

The application toolbar has four buttons; Copy, Print, Print Preview, and About. The functionality of these buttons are identical to their corresponding main menu items. Many of the menu items and toolbar buttons are sensitive to the type and state of the active view, and will be selectively enabled and disabled as necessary.

Table 8. Application Menu Items

Menu Item	Popup Item	Description
File	Open Database	Opens an existing main database file
	New Database	Creates a new main database file
	Commit Current	Commits the current changes made to the database associated with the active view
	Revert Current	Reverts the current changes made to the database associated with the active view
	Print	Prints the data associated with the active view
	Print Preview	Displays a preview window of the printed data associated with the active view
	Print Setup	Displays the printer selection and setup dialog
	Exit	Terminates the CADET application
Reports	Create	Creates a new set of analysis results
	View	View existing analysis results
	Purge	Deletes the files associated with a set of analysis results
Edit	Copy	Places the data associated with the active view into the clipboard
View	Toolbar	Toggles the display of the application toolbar
	Status Bar	Toggles the display of the status bar on the main application window
	Cascade	Positions child windows so they are laid out in a cascading manner
	Tile	Positions child windows so they are laid out in a tiled manner
	Arrange Icons	Rearranges the icons in the main application window that represent minimized child windows
Help	Help Topics	Displays the on-line help system for the application
	About Channel Design Tool	Displays a window showing application version information

SUMMARY

The CADET software was developed to aid the US Army Corps of Engineers determine the best dredge depth of harbor entrance channels for deep draft ships by providing channel accessibility curves. This manual documents the theory and practice of the CADET software, which was developed by the Seakeeping Department at the Carderock Division, Naval Surface Warfare Center. If assistance is needed for using this software or understanding the results, please contact Mr. Paul Kopp at (301) 227-5925 or koppj@nswccd.navy.mil or Mr. Andrew Silver at (301) 227-5119 or silveral@nswccd.navy.mil.

APPENDIX A - DATA FILE DESCRIPTIONS

CADET and its component programs utilize and create many different types of data files. With the exception of the motion transfer function files, all are ASCII format files. The three primary database file types used by CADET are formatted using the Extensible Markup Language (XML). This Appendix documents the formatting and contents of the files used by CADET and its component programs.

XML DATA FORMATTING

The Extensible Markup Language (XML) is a subset of the Standard Generalized Markup Language (SGML), which was made an International Standards Organization (ISO) standard in 1986. Like SGML, XML allows for the development of a markup language for an entire industry or a single specific problem. A markup language consists primarily of elements, attributes that modify elements, and the contents of the elements. The most widely known markup language, also a subset of SGML, is the Hypertext Markup Language (HTML), used for web document creation.

Elements are defined by tags that delimit the start and end of the element. Tags are delimited by angle brackets (< and >). Through the use of tags, elements, and attributes, complex data hierarchies may be represented. In the example XML representation below, two primary elements are declared for two ships. Each of these elements declares subordinate elements.

```
<Ship Name="ship A">
        <Length>100</Length>
        <Beam>22</Beam>
        <Draft>12</Draft>
        <Propulsion Type="Diesel" MaxHP="2500"/>
</Ship>
<Ship Name="ship B">
        <Length>124</Length>
        <Beam>26</Beam>
        <Draft>17</Draft>
        <Propulsion Type="Turbine" MaxHP="5700"/>
</Ship>
```

The first element is a Ship type with a single attribute identified as Name. The Name attribute has a value "ship A". Attributes are always treated as a string and are in double quotes. There are four elements subordinate to the Ship element; Length, Beam, Draft, and Propulsion. The first three elements have content that is given between the starting and ending tags for each element. An ending tag can be identified by the forward slash (/) before the element name in the tag, after the opening angle bracket (<) and must be matched with a starting tag. Note that the Propulsion element tag has two attributes of its own and that it ends with a forward slash (/) before the closing angle bracket (>). This ending forward slash identifies the tag as stand alone, with content or child tags.

Following the ending tag for the first Ship element is the starting tag for another Ship element. While in this case, the layout and naming of the child elements is identical to that in the first Ship element, this does not have to be. The complete XML specification defines many structural elements and a flexible grammar and syntax. The XML file reader utilized by CADET uses canonical XML, which does not utilize features such as the document prolog. The XML reader parses the entire file and builds a tree containing tags at the nodes. The tree representation is then processed. Unexpected tag names and attributes are generally ignored.

MAIN DATABASE FILE

The main database file is read by CADET at program startup, from the starting directory. The file name by default is assumed to be "Database.xml". If CADET can not find this file, it will prompt the user to select a different main database file, with no assumptions about the file name. The main database file defines the ships and projects available in the database, along with information about the component programs used by CADET. The file is assumed to be XML format with tags and attributes named and structured according to Table A1 (see page 55).

An example main database file is shown in Listing A1. Note that there is a single top level element named "ChannelTool". This identifies the tag structure as being a main database for CADET. The three subordinate elements are named Database, Projects, and Programs. Initially, when a new main database is created, there will be no ships in the database or projects defined. The Programs tag is required to be populated with the six specified child tags. These are used to identify and locate the component programs used by CADET. Note that the link for SCORES is a batch command file used to run the SCORES executable program. The Port and Vessel tags both define a link attribute which is used to specify XML data files for the project and ship databases, respectively.

Listing A1. Example CADET Main Database File

```
<ChannelTool>
   <Database>
      <Vessel type="Destroyer" name="DDG51"
link="data/ships/DDG51/DDG51.xml"/>
      <Vessel name="CG47" type="Cruiser" link="Data/Ships/CG47/CG47.xml"/>
   </Database>
   <Projects>
      <Port link="data/projects/Norfolk/Norfolk.xml">
         <name>Norfolk</name>
         <location>Norfolk, VA</location>
      </Port>
      <Port link="Data/Projects/SanDiego/SanDiego.xml">
         <name>SanDiego</name>
         <location>San Diego, CA</location>
      </Port>
   </Projects>
   <Programs>
      <Geo2Scores link="c:\CADET\bin\Geo2Scores.exe"/>
      <Scores link=" c:\CADET\bin\runscores.bat"/>
      <Compress link=" c:\CADET\bin\CompressXfer.exe"/>
      <Imot link=" c:\CADET\bin\Imot.exe"/>
      <NefRisk link=" c:\CADET\bin\RiskAnalysis.exe"/>
      <Access link=" c:\CADET\bin\Access.exe"/>
   </Programs>
</ChannelTool>
```

SHIP DATABASE FILE

The ship database file is an XML format file that is used to define the information about a single ship, including geometry, loading conditions, and motion transfer functions. The required tags and structure of the file is given in Table A2 (see page 56). The main element is the ShipRecord tag, having attributes name, type, and geofile. The name and type attributes should be identical to the corresponding tag for the ship in the main database file. The geofile attribute specifies a link to an external data file, described in the proceeding section, that defines the ship hull

geometry and geometric characteristics. There is only one type of element associated with a ShipRecord tag, the Condition tag.

The Condition tag is used to define a loading condition for the ship and includes (among others) child tags for specifying the draft and trim, location of control points, mass properties, and the motion transfer functions for the ship in the specified loading condition. A Condition has two attributes, a label for naming the loading condition and a directory (path) name that is used for storing motion transfer functions for the loading condition. The path is assumed to be a subdirectory, relative to the location of the ship database file. Child elements for each loading condition correspond to the tree display items given in Table A2.

GEOMETRY DESCRIPTION FILE

The ship geometry description data file is a file that can be created and manipulated from CADET or generated externally. The file is referenced by a ship database and is used to define the underwater hull form at a particular loading condition. The hull surface should therefore be defined up to the deck at edge, or at least, up to the deepest loaded waterline. The ship geometry file is formatted according the geo-file format, developed by John Dalzell at NSWCCD, and provides an analysis application neutral representation of ship geometry. The data records expected in the file are given in Table A3 (see page 59). For an example of a geometry data file, see one of the sample files included in the CADET installation.

Offset points are defined along with a point type that controls how spline curves are fit to the data. A normal point type has continuous first and second order continuity in the curve at the point. An end line point specifies a point assumed to be at the end of a straight line from the preceding point and which does not necessarily have first order continuity. A start line point specifies a point assumed to be at the start of straight line to the proceeding point and which does not necessarily have first order continuity. Break points are used to specify simple first order slope discontinuities.

SINKAGE AND TRIM DATA FILE

The sinkage and trim induced on a vessel transiting through shallow water is a complicated problem in its own right. It is a result of the pressure field acting on the hull surface due to the waves generated by the moving body, interacting with the bottom topography. For any given topography, water depth and ship speed are the controlling parameters. CADET refers to external data file prepared according to the format specified here. This file may be created using data obtained from model tests, full-scale measurements, or empirical or analytical methods. These are discussed in the open literature[1].

Sinkage and trim data is given in an ASCII file that contains the vertical sinkage (positive down) and trim angle (degrees positive bow down) versus the Froude number based on water depth, as given in Equation A1.

$$F_{n_{depth}} = V_s / \sqrt{gH} \tag{A1}$$

[1] For example, "Workshop on Ship Squat in Restricted Waters", SNAME Panel H-10, 1996.

where H is the water depth, g is the gravitational acceleration constant, and Vs is the ship speed. The data file supports an optional fourth value in the tabulated data for grouping results by water depth. When this is done, those water depths values should match the project depths used when performing a risk analysis.

An example of a sinkage and trim data file is shown in Listing A2. The first line specifies the number of subsequent data lines to read. When this is a positive value, then the water depth column is not read and the tabulated data must be sorted by increasing Froude number based on depth. When the number of data lines is a negative value, as it is in the example, then the water depth column is read and it is assumed that the sorting is by increasing water depth first and then by increasing Froude number based on depth. All data lines are read free format, without regard to column position. The first column is Froude number based on depth, then sinkage, trim angle, and water depth.

Listing A2. Example Sinkage and Trim Data File

```
-49
0.094156739 0.03        -0.002048718    40.0
0.188313477 0.13        -0.008194872    40.0
0.282470216 0.3                -0.018438461    40.0
0.376626954 0.535       -0.033803843    40.0
0.470783693 0.845       -0.052242295    40.0
0.564940432 1.275       -0.074778165    40.0
0.65909717  1.87        -0.10038708     40.0
0.753253909 2.76        -0.129069016    40.0
0.093001397 0.03        -0.002048718    41.0
0.186002795 0.13        -0.008194872    41.0
0.279004192 0.295       -0.01946282     41.0
0.37200559  0.52        -0.034828202    41.0
0.465006987 0.83        -0.053266653    41.0
0.558008385 1.24        -0.075802522    41.0
0.651009782 1.82        -0.102435791    41.0
0.744011179 2.67        -0.131117724    41.0
0.091887568 0.03        -0.002048718    42.0
0.183775136 0.13        -0.008194872    42.0
0.275662704 0.285       -0.01946282     42.0
0.367550272 0.51        -0.034828202    42.0
0.45943784  0.81        -0.053266653    42.0
0.551325408 1.215       -0.076826879    42.0
0.643212976 1.77        -0.104484503    42.0
0.735100544 2.58        -0.133166431    42.0
0.090812823 0.03        -0.002048718    43.0
0.181625645 0.125       -0.009219231    43.0
0.272438468 0.285       -0.01946282     43.0
0.363251291 0.5         -0.034828202    43.0
0.454064113 0.795       -0.054291011    43.0
0.544876936 1.19        -0.077851236    43.0
0.635689759 1.73        -0.104484503    43.0
0.726502581 2.495       -0.134190784    43.0
0.089774928 0.03        -0.002048718    44.0
0.179549856 0.125       -0.009219231    44.0
0.269324783 0.275       -0.01946282     44.0
0.359099711 0.49        -0.034828202    44.0
0.448874639 0.785       -0.054291011    44.0
0.538649567 1.165       -0.078875594    44.0
0.628424494 1.685       -0.105508858    44.0
0.718199422 2.425       -0.136239491    44.0
0.088771824 0.03        -0.002048718    45.0
0.177543649 0.12        -0.008194872    45.0
0.266315473 0.275       -0.01946282     45.0
0.355087298 0.485       -0.03585256     45.0
0.443859122 0.77        -0.055315369    45.0
0.532630947 1.145       -0.078875594    45.0
0.621402771 1.645       -0.105508858    45.0
0.710174596 2.36        -0.137263844    45.0
```

TRANSFER FUNCTION DATA FILE

Seakeeping motion transfer functions are generated from the hull surface description and mass properties using the shallow water, frequency domain, strip theory based SCORES computer program. However, to allow CADET the flexibility to utilize transfer functions from other sources, the transfer functions from SCORES are converted into a neutral format, described here. CADET utilizes a component program, COMPRESSXFER, to read the raw SCORES output file and write the heave, pitch, and roll transfer functions to an unformatted binary file.

The binary transfer function file is written (by COMPRESSXFER) and read (by IMOT) by programs developed in FORTRAN which uses unformatted reads and writes. In general, FORTRAN compilers are free to implement record marking in any way they choose. This leads to problems with exchanging unformatted files between programs created using different compilers. Programs created in other programming languages, needless to say, suffer the same problem. Listing A3 shows sample program code that could be used to write a binary transfer function file.

Listing A3. Example FORTRAN Program Pseudo-Code for Writing Binary Transfer Function Files

```
CHARACTER TITLE*80
PARAMETER(NVK=3)                                ! number of velocities
PARAMETER(NOMEGAMAX=30)                         ! number of frequencies
PARAMETER(NHDGMAX=13)                           ! number of headings
PARAMETER(NRANGMAX=8)                           ! number of mean roll angles
DIMANSION OMEGA(NOMEGAMAX)                      ! wave frequencies
DIMENSION OMEGAE(NOMEGAMAX,NHDGMAX)             ! encounter frequencies
DIMENSION RLANG(NRANGMAX)                       ! mean roll angles in xfer fns.
DIMENSION HEADANG(NHDGMAX)                      ! headings (0 head, 180
following)
COMPLEX HV(NOMEGAMAX,NHDGMAX)                   ! real/imaginary heave xfer fns.
COMPLEX PIT(NOMEGAMAX,NHDGMAX)                  ! real/imaginary pitch xfer fns.
COMPLEX ROLL(NRANGMAX,NOMEGAMAX,NHDGMAX)        ! real/imaginary roll xfer fns.

TITLE = ...as appropriate...
OMEAG = ...fill in wave frequencies...

GRAV = 32.174                                   ! gravitational constant
DO I=1,NHDGMAX
  HEADANG(I) = I*15.0                           ! 15 deg heading increments
END DO
NRANG = 1                                       ! only one supported in CADET
RLANG(1) = 0.0

OPEN(UNIT=10,STATUS='UNKNOWN',FORM='UNFORMATTED')

WRITE(10) TITLE,NVK,NMU,NOMEGA,NRANG,OMEGA,RLANG,GRAV

DO I=1,NVK
  VKK = ...each speed...
  OMEGAE = ...recomputed for new speed...
  HV = ...fill in complex heave transfer functions for new speed...
  PIT = ...fill in complex heave transfer functions for new speed...
  ROLL = ...fill in complex heave transfer functions for new speed...
  WRITE(10) VKK,HEADANG,OMEGAE,HV,PIT,ROLL
END DO

CLOSE(10)
```

Notice that the roll transfer function has an extra dimension to accommodate the use of a quasi non-linear roll iteration, as developed for the Navy Standard Ship Motion Program (SMP). However, since SCORES does not provide roll transfer functions about different mean roll angles, the number of roll angles in the example program

listing is fixed at one. The dimensions of the arrays declared are specified by the values in the parameter statements. These values should not be changed since they are the sizes assumed by the IMOT component program.

TRANSFER FUNCTION COMPARISON DATA FILE

The transfer function explorer view, shown in Figure 11, has controls that allow external data to be plotted along with the transfer function data being examined. The data is assumed to be in a free format ASCII file, created outside of CADET. The file may contain multiple data sets, each representing the motion transfer functions for a specific combination of speed, heading, water depth, etc. When the file is read by CADET, the user is prompted to select one of the data sets in the file for display. Table A4 (see page 61) lists the expected contents of the data file. Listing A4 shows an example comparison data file containing two sets of data. In this case, the known data is the non-dimensional wave length and the heave and pitch amplitude and phase. The unknown data values for frequency, frequency of encounter, and roll amplitude and phase are given as zeros.

Listing A4. Example Transfer Function Comparison Data File

```
2
459.33
8 kts, 0 deg, 46ft depth
0 0
12
0.0 0.0 0.2    0.015   -164.12 0       170.82 0.0 0.0
0.0 0.0 0.35   0.015   -92.49  0       -118.95 0.0 0.0
0.0 0.0 0.5    0.078   29.33   0.024   -19.8 0.0 0.0
0.0 0.0 0.75   0.34    1.83    0.456   165.87 0.0 0.0
0.0 0.0 0.75   0.377   5.45    0.486   176.94 0.0 0.0
0.0 0.0 0.85   0.327   60.49   0.768   -144.66 0.0 0.0
0.0 0.0 0.85   0.379   60.49   0.827   -152.77 0.0 0.0
0.0 0.0 1      0.196   8.5     0.851   -102.33 0.0 0.0
0.0 0.0 1      0.181   0.5     0.81    -95.69 0.0 0.0
0.0 0.0 1.15   0.316   13.97   0.706   -87.33 0.0 0.0
0.0 0.0 1.25   0.336   23.15   0.696   -102.65 0.0 0.0
0.0 0.0 1.5    0.466   -3.62   0.885   -94.12 0.0 0.0
8 kts, 45 deg, 46ft depth
0 0
9
0.0 0.0 0.2    0.015   -122.86 0       -165.95 0.0 0.0
0.0 0.0 0.35   0.028   31.2    0       72.62 0.0 0.0
0.0 0.0 0.5    0.042   -83.16  0.043   131.079 0.0 0.0
0.0 0.0 0.75   1.108   -42.83  0.68    171.48 0.0 0.0
0.0 0.0 0.85   0.491   -37.33  0.585   -146.766 0.0 0.0
0.0 0.0 1      0.458   -28.74  0.691   -117.57 0.0 0.0
0.0 0.0 1.15   0.573   -27.67  0.63    -113.89 0.0 0.0
0.0 0.0 1.25   0.616   -37.15  0.701   -111.695 0.0 0.0
0.0 0.0 1.5    0.819   -17.09  0.791   -104.309 0.0 0.0
```

FILES USED BY GEO2SCORES

The GEO2SCORES component program is used to generate a skeleton input file for SCORES that contains the hull offsets up to the waterline at a specified loading (draft and trim). This skeleton file is used to generate the actual SCORES input files as necessary. GEO2SCORES is a command line program, written in FORTRAN. It prompts the user for name of a geometry data file, as previously discussed, the name of the skeleton output file, the number of desired offsets for each station, if the offsets are desired up to the waterline, and the drafts at the forward

and aft perpendicular. When GEO2SCORES is executed from within CADET, the user responses are placed in a temporary file named geoconv.tmp, in the main database directory location. This response file is piped to GEO2SCORES and the responses read from the file as if they were typed at the keyboard.

FILES USED BY SCORES

While the SCORES program is used as a component of CADET, it is a stand alone, general commercial program in its own right. Only the input data file and the output file containing the transfer functions are used as part of the interface with CADET. Discussion of the other files created and used by SCORES are beyond the scope of this report. Descriptions of the input and output files may be found in the documentation for SCORES [10].

A batch command file is used as a pre-processor to SCORES. This batch file renames the input file to "scores.in" which is the name assumed by the SCORES executable. It then executes SCORES and renames the output file generated from "scores.out" to the specified output file name. Before terminating, the batch file deletes the other files generated by SCORES. This batch command file is the one that is specified in the main database (see Listing A1).

PROJECT DATABASE FILE

The project database file is an XML format file that is used to define the information about a channel design being analyzed, including the geometry of the reaches, wave conditions in the reaches, persistence of the wave environment, and the ships and their loading conditions that transit the channel reaches. The required tags and structure of the file is given in Table A5 (see page 62). The main element is the ProjectRecord tag, having attributes name and location. These attributes should be identical to the corresponding tag for the project in the main database file.

Channel reaches are defined by a Reach element that has many attributes. The attributes expected are detailed in Table A5. The Reach element has one child element type, WaveData. The WaveData tag declares attributes that specify a link to an external wave spectra data file, the significant wave height, modal period, and dominate wave direction, and the probability of occurrence of the wave spectral representation. The significant wave height, modal period, and dominate direction are obtained from the header record of the wave spectra data file when the link to the data file is made inside of CADET. A Reach element appears in the project database file for each reach defined for a project.

The Selection element contains child elements, Condition, with attributes that specify a specific ship and loading condition used in the analysis. The ShipLink attribute specifies a ship database file while the CondLink attribute specifies the name of a particular loading condition for that ship.

The Report element is used to identify individual sets of analysis results (a results database). A Path attribute is used to identify the location of the results database file. A relative path specified is treated as relative to the location of the main database file. An attribute, Created, is used to provide a time stamp identifying when the analysis was performed.

The Comment element is used to provide textual comments, notes, and other information related to a project. The text of the comment is taken from the content of the element. Multiple Comment elements may be used. All of the data specified in the elements and attributes of the project database file have corresponding representations in the display views of a project database (see Figures 13, 14, 16, and 17).

WAVE SPECTRA DATA FILE

The wave environment for a channel reach is expressed as a collection of representative wave spectra files, each having a specified probability of occurrence. These spectra files are prepared external to CADET and referenced through the project database as previously described. They are assumed to be free format ASCII files.

The first line is the file header and specifies the significant wave height (in meters), model wave period (seconds), and dominate direction (degrees). Two numeric values, which are not used by CADET and may be set to zero, are located at the start of the header line, The second line identifies the directions in 15 degree increments, starting from 0 and ending at 345 degrees. Subsequent lines (up to a maximum of 45) specify the wave frequency and spectral ordinates at each heading. Wave frequencies are expected in radians/second and spectral ordinates are expected in ft^2-sec. Listing A5 shows an abbreviated sample wave spectra data file.

Listing A5. Sample Wave Spectra Data File

```
0  0    1.20   10.90   90.00
          0.0         15.0        30.0        ...     315.0       330.0       345.0
0.0080 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0160 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0230 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0310 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0390 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0470 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0550 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0620 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0700 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0780 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0860 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.0940 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.1010 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.1090 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.1170 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.1250 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
   .       .            .           .                    .           .           .
   .       .            .           .                    .           .           .
   .       .            .           .                    .           .           .
0.2890 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.2960 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.3040 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.3120 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.3200 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.3280 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.3350 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.3430 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
0.3510 0.00000E+00 0.00000E+00 0.00000E+00    ...    0.00000E+00 0.00000E+00 0.00000E+00
```

RESULTS DATABASE FILE

The results database file is an XML format file that is used to define information about the inputs used to perform an analysis and the results from the analysis. When an analysis is performed in CADET, the results database file is created prior to performing any analysis functions. The contents of the database file are used to control the generation of the input and temporary files used by the IMOT, RISKANALYSIS, and ACCESS component programs. The required tags and structure of the file is given in Table A6 (see page 63). It can be seen that the results database file is an amalgamation of the information the ship database files (for the selected ships) and the project database file.

IMOT PROGRAM INPUT FILE

The IMOT component program is a stand alone, command line program, that uses the motion transfer functions and wave spectra data to compute the vertical motion displacement and velocity variances. IMOT uses a single input file specified on the command line when IMOT is executed. The first line of the input file specifies the file name and location of the motions transfer function file to use. The second line specifies the name and location of the output file created by IMOT. The third line indicates the channel reach number assumed for the run. The fourth line specifies the name and location of the IMOT parameter file. The fifth line identifies the name and location of a file that lists the names and locations of wave spectra data files for the channel reach specified on the third line of the input file. The last line provides a title line to be used as a title in the output file created by IMOT. When IMOT is run from within CADET during an analysis, creation of the IMOT input file is automatic. Listing A6 shows a sample IMOT input file.

Listing A6. Example IMOT Program Input File

```
Data/Ships/WorldUtility/FullLoad/FullLoad_42.bin
Data/Projects/Norfolk/Study/Worldutility_FullLoad/Imot-1-42.mom
1
Data/Projects/ Norfolk/Study/Worldutility_FullLoad/Imot.tmp
Data/Projects/ Norfolk/Study/Worldutility_FullLoad/Wavefiles-1.tmp
World Utility: Reach 1, Depth 42 ft
```

An IMOT input data file is created for each channel reach in the project, each candidate water depth in the reach, and each ship/loading condition combination. The naming convention for the input file, when automatically created by CADET, is IMOT-<reach number>-<water depth>.inp where the water depth is given as an integer.

IMOT PROGRAM PARAMETER INPUT FILE

The IMOT parameter input file provides the IMOT component program with information about the ship speeds, headings of the channel reaches (outbound angles in degrees), and the location on the ship of the 5 primary control points (and up to 4 additional control points). The file assumed to be ASCII, free format. A sample parameter input file is shown in Listing A7.

Listing A7. Example IMOT Parameter Input File

```
8 10 12
2
90
130
5
259.34 0 0
-299.994 0 0
-299.994 0 0
-20.327 0 0
-20.327 0 0
```

The first line specifies the three ship speeds (knots, integer value). The second line specifies the number of channel reaches with a corresponding number of subsequent line specifying the outbound transit heading angle (degrees) for the reaches. The next line specifies the number of control points with a corresponding number of subsequent lines identifying the x,y,z spatial location (feet positive forward of the center of gravity, starboard, above the baseline) of each control point. This file is created automatically (and named imot.tmp) when IMOT is executed from with CADET. One IMOT parameter input file is created for each ship/loading condition combination.

IMOT PROGRAM WAVE LIST INPUT FILE

The wave list input file provides IMOT with a list of the file names and location of the wave spectra data files used by IMOT during an analysis. Two lines are used for each wave spectra data file specified, the first giving the probability of occurrence of the spectra and the second giving the name and location of the data file. The wave list input file is assumed to be ASCII, free format. When the wave list file is created automatically by CADET, it is named wavefiles-<reach number>.tmp.

IMOT PROGRAM OUTPUT (MOM) FILE

The output file from IMOT contains the vertical displacement and velocity motion variances for each wave condition, transit direction, ship speed, and control point. A sample of the first portion of an IMOT output is shown in Listing A8.

Listing A8. Example IMOT Output File

```
Trident: Reach 1, Depth 42 ft
    1     0.20    10.90     0.00      0.80
  90.0   8.0   0.4825E-01   0.5345E-01   0.5345E-01   0.4141E-01   0.4141E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.8056E-03   0.9237E-03   0.9237E-03   0.6457E-03   0.6457E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  90.0  10.0   0.4835E-01   0.5370E-01   0.5370E-01   0.4163E-01   0.4163E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.8773E-03   0.1013E-02   0.1013E-02   0.7016E-03   0.7016E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  90.0  12.0   0.4845E-01   0.5403E-01   0.5403E-01   0.4188E-01   0.4188E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.9536E-03   0.1111E-02   0.1111E-02   0.7621E-03   0.7621E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 270.0   8.0   0.4797E-01   0.5286E-01   0.5286E-01   0.4015E-01   0.4015E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.3990E-03   0.4386E-03   0.4386E-03   0.3408E-03   0.3408E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 270.0  10.0   0.4799E-01   0.5299E-01   0.5299E-01   0.4005E-01   0.4005E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.3671E-03   0.4019E-03   0.4019E-03   0.3181E-03   0.3181E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 270.0  12.0   0.4804E-01   0.5317E-01   0.5317E-01   0.3997E-01   0.3997E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.3391E-03   0.3700E-03   0.3700E-03   0.2985E-03   0.2985E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
    2     0.20    10.90     0.00      0.80
  90.0   8.0   0.4602E-01   0.4957E-01   0.4957E-01   0.4149E-01   0.4149E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.5551E-03   0.6062E-03   0.6062E-03   0.4944E-03   0.4944E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  90.0  10.0   0.4605E-01   0.4971E-01   0.4971E-01   0.4153E-01   0.4153E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.5659E-03   0.6201E-03   0.6201E-03   0.5051E-03   0.5051E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  90.0  12.0   0.4608E-01   0.4988E-01   0.4988E-01   0.4160E-01   0.4160E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.5788E-03   0.6374E-03   0.6374E-03   0.5183E-03   0.5183E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 270.0   8.0   0.4602E-01   0.4957E-01   0.4957E-01   0.4149E-01   0.4149E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.5551E-03   0.6062E-03   0.6062E-03   0.4944E-03   0.4944E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 270.0  10.0   0.4605E-01   0.4971E-01   0.4971E-01   0.4153E-01   0.4153E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.5659E-03   0.6201E-03   0.6201E-03   0.5051E-03   0.5051E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 270.0  12.0   0.4608E-01   0.4988E-01   0.4988E-01   0.4160E-01   0.4160E-01 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
               0.5788E-03   0.6374E-03   0.6374E-03   0.5183E-03   0.5183E-03 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
    .
    .
    .
    .
```

The first line is the title as specified in the IMOT input file. The output is grouped according to the wave conditions specified in the IMOT wave list input file, with 13 lines for each wave condition. The first line for a wave condition contains the number of the wave condition, significant wave height (meters), modal period (seconds), dominate wave direction (degrees), and the significant wave height computed from the spectra (meters). The lines following for a wave condition are divided into groups of two lines each. Each of these are for the heading (degrees) and ship speed (knots) indicated as the first two numbers in first line of the group. The following nine numbers are the vertical displacement variances computed for each of the (maximum of) nine control points. The second line of the group has nine values for the corresponding vertical velocity variances of the control points.

RISK ANALYSIS PROGRAM INPUT FILE

The risk analysis program input file defines the files used for a single run of the risk calculation component program. This file is ASCII, free format and contains the names and locations of several files, one per line. The first file is the output file from the IMOT program, which contains the control point vertical displacement and velocity variances. The second file is the name of the risk output file created by the risk component program. The third is the name of the file containing the motion allowances for each control point and the fourth is the name of the static (plus sinkage and trim) clearances for each control point. The fifth line specifies the name of the risk analysis program parameter input file. The sixth line specifies the name of the sinkage and trim data file for a particular ship and loading condition. The last two line identify the channel reach number and water depth (feet, integer) respectively. When the risk analysis component program is executed from within CADET, the input file is created automatically. An input file is created for each channel reach, candidate water depth, and ship/loading condition combination and is named NefRsk-<reach number>-<water depth>.mom where the water depth is an integer. Listing A9 shows a sample input file.

Listing A9. Example Risk Analysis Program Input File

```
Data/Projects/Norfolk/Study/WorldUtility_FullLoad/Imot-1-42.mom
Data/Projects/Norfolk/Study/WorldUtility_FullLoad/Risk-1-42.rsk
Data/Projects/Norfolk/Study/WorldUtility_FullLoad/Allowance-1-42.rsk
Data/Projects/Norfolk/Study/WorldUtility_FullLoad/Clearance-1-42.rsk
Data/Projects/Norfolk/Study/WorldUtility_FullLoad/Nefrsk-1.tmp
D:\Projects\ChannelDesignTool\Data/Ships/WorldUtility\sinkage.dat
1
42
```

RISK ANALYSIS PROGRAM PARAMETER INPUT FILE

The risk analysis component program parameter input file is an ASCII, free format file that provides information that is independent of the water depth and reach. This file is created automatically when the risk component program is executed from with CADET. One file is created for each channel reach and ship/loading condition combination. The file named NefRsk-<reach number>.tmp. Listing A10 show a sample parameter file.

Listing A10. Example Risk Analysis Program Parameter Input File

```
35.75
-0.045072
27.9667
0.8
0
0
0.1
0.01
2
0.7
5.5
5
0 0
20 0
20 0
10 0
10 0
```

The first line specifies the ship draft at midship (feet), the second is the trim angle (degrees positive bow down), then the ship station spacing (feet), followed by the correlation coefficient between displacement and velocity. The next two lines specify the vertical clearance offset (feet) for the primary and alternate control points, respectively. The next line specifies the assumed coefficient of variation of displacement and velocity standard deviations. The next line is the motion risk parameter (see Equation 1). The following line gives the number channel reaches, followed by lines containing the reach length (nautical miles) for each reach. Next is a line containing the number of control points, with subsequent lines for the longitudinal position (station number) and transverse location of each of the control points.

RISK ANALYSIS PROGRAM OUTPUT FILE

The risk analysis component program output file is an ASCII file containing the limiting control point identifiers, associated risks of touching, and clearances. A sample of an output file is shown in Listing A11.

Listing A11. Example Risk Analysis Program Output File

```
  42.00
Trident: Reach 1, Depth 42 ft
   1     0.20    10.90     0.00      0.80
           90.00     8.00    3     5.30  0.0001  0.0001     9     6.13  0.0001  0.0001
           90.00    10.00    3     5.10  0.0001  0.0001     9     5.92  0.0001  0.0001
           90.00    12.00    3     4.82  0.0001  0.0001     9     5.63  0.0001  0.0001
          270.00     8.00    3     5.33  0.0001  0.0001     9     6.13  0.0001  0.0001
          270.00    10.00    3     5.13  0.0001  0.0001     9     5.92  0.0001  0.0001
          270.00    12.00    3     4.86  0.0001  0.0001     9     5.63  0.0001  0.0001
   2     0.20    10.90     0.00      0.80
           90.00     8.00    3     5.34  0.0001  0.0001     9     6.13  0.0001  0.0001
           90.00    10.00    3     5.14  0.0001  0.0001     9     5.92  0.0001  0.0001
           90.00    12.00    3     4.86  0.0001  0.0001     9     5.63  0.0001  0.0001
          270.00     8.00    3     5.34  0.0001  0.0001     9     6.13  0.0001  0.0001
          270.00    10.00    3     5.14  0.0001  0.0001     9     5.92  0.0001  0.0001
          270.00    12.00    3     4.86  0.0001  0.0001     9     5.63  0.0001  0.0001
        .
        .
        .
```

The first line gives the water depth as a floating point number, followed by a line containing the title (as specified in the IMOT input file).`The data is grouped according to wave condition, with 7 lines fur each wave condition. The first line for a wave condition contains the number of the wave condition, significant wave height (meters), modal period (seconds), dominate wave direction (degrees), and the significant wave height computed from the spectra (meters). Each of the subsequent six lines contains (in order), the heading angle (degrees), ship speed (knots), limiting primary control point number, the corresponding clearance and risk of touching a flat bottom and a bottom with random variation. The last four numbers in each line identify the limiting alternate control point, clearance at that point, and risk of touching a flat bottom and bottom with random variation.

RISK ANALYSIS PROGRAM ALLOWANCE OUTPUT FILE

The risk analysis component program creates a motion allowance output file. That contains the motion allowance values for each control point and each wave condition, ship speed, and heading combination. Listing A12 show a sample motion allowance output file.

The first line gives the water depth as a floating point number, followed by a line containing the title (as specified in the IMOT input file). The data is grouped according to wave condition, with seven lines for each wave condition. The first line for a wave condition contains the number of the wave condition, significant wave height (meters), modal period (seconds), dominate wave direction (degrees), and the significant wave height computed from the spectra (meters). Each of the subsequent six lines contains (in order), the heading angle (degrees), ship speed (knots). Nine numbers follow on each line, one for the motion allowance of each of the control points.

Listing A12. Example Risk Analysis Program Allowance Output File

```
  42.00
Trident: Reach 1, Depth 42 ft
   1    0.20    10.90     0.00     0.80
          90.00    8.00     0.79     0.83     0.83     0.73     0.73     0.00     0.00     0.00     0.00
          90.00   10.00     0.78     0.82     0.82     0.72     0.72     0.00     0.00     0.00     0.00
          90.00   12.00     0.77     0.82     0.82     0.71     0.71     0.00     0.00     0.00     0.00
         270.00    8.00     0.77     0.80     0.80     0.70     0.70     0.00     0.00     0.00     0.00
         270.00   10.00     0.75     0.79     0.79     0.69     0.69     0.00     0.00     0.00     0.00
         270.00   12.00     0.74     0.77     0.77     0.67     0.67     0.00     0.00     0.00     0.00
   2    0.20    10.90     0.00     0.80
          90.00    8.00     0.76     0.79     0.79     0.72     0.72     0.00     0.00     0.00     0.00
          90.00   10.00     0.75     0.78     0.78     0.71     0.71     0.00     0.00     0.00     0.00
          90.00   12.00     0.74     0.77     0.77     0.70     0.70     0.00     0.00     0.00     0.00
         270.00    8.00     0.76     0.79     0.79     0.72     0.72     0.00     0.00     0.00     0.00
         270.00   10.00     0.75     0.78     0.78     0.71     0.71     0.00     0.00     0.00     0.00
         270.00   12.00     0.74     0.77     0.77     0.70     0.70     0.00     0.00     0.00     0.00
     .
     .
     .
```

RISK ANALYSIS PROGRAM CLEARANCE OUTPUT FILE

The risk analysis component program creates an underkeel clearance output file that contains the clearance values for each control point and each wave condition, ship speed, and heading combination. Listing A13 show a sample clearance output file. This file contains three lines, one for each speed specified as the first value on the line. Nine other number follow on each line, and are the clearances corresponding to the nine control points.

Listing A13. Example Risk Analysis Program Clearance Output File

```
  8.00    6.13    6.13    6.13    6.13    6.13    6.13    6.13    6.13    6.13
 10.00    5.92    5.92    5.92    5.92    5.92    5.92    5.92    5.92    5.92
 12.00    5.63    5.63    5.63    5.63    5.63    5.63    5.63    5.63    5.63
```

ACCESS PROGRAM INPUT FILE

The ACCESS program input file defines the files used for a single run of the accessibility calculation component program. This file is ASCII, free format and is named access-<reach number>.inp when created from within CADET. This file contains numeric input as well as the names and locations of several files, one per line. The first file is the wave list input file used with the IMOT program. The second file is the name of the output file that is created by ACCESS. The third line specifies the three ship speeds (knots, integer value), with the reach number being considered on the following line. The next line contains the motion risk parameter (see Equation 1). The next two lines contain the vertical offset required for the primary and alternate control points, respectively. The following line specified the number of alternate control points to consider. The next line indicates the number of water depths considered for the reach. The names of the risk analysis component program output files are given on subsequent lines, one for each of the water depths. Finally, the names of the risk analysis component program clearance output files are given, one for each of the water depths.

Listing A14. Example Access Program Input File

```
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Wavefiles-2.tmp
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline\Access-2.dat
8 10 12
2
0.01
0
0
0
5
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Risk-2-42.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Risk-2-44.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Risk-2-46.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Risk-2-48.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Risk-2-50.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Clearance-2-42.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Clearance-2-44.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Clearance-2-46.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Clearance-2-48.rsk
Data/Projects/Emogs/NOTU\ScoresXferFns/Trident_Baseline/Clearance-2-50.rsk
```

ACCESS PROGRAM OUTPUT FILE

The output file from the accessibility calculation component program, ACCESS, contains the expected number of days of accessibility for a particular reach, for each of the candidate water depths and for each ship speed, in both inbound and output transit directions. Listing A15 shows a sample output file. Notice that there are two sets of accessibility values presented for both inbound and outbound transits. The set on the left portion of the table is for the accessibility considering the primary control points. The set on the right portion of the table is for the accessibility considering the alternate control points.

Listing A15. Example Access Program Output File

```
DAYS OF ACCESS PER YEAR FOR REACH  1
 FOR DIFFERENT PROJECT DEPTHS (101.67 CALM DAYS)
  If risk of grounding is less than 0.010000
  then access is assumed granted.
  Project Depth  Days of Access/Yr
       (ft)        Outbound                     Inbound                      Outbound                     Inbound
                     8KTS    10KTS    12KTS      8KTS    10KTS    12KTS      8KTS    10KTS    12KTS      8KTS    10KTS    12KTS
      42.0         328.31   326.54   319.51    339.44   339.44   336.82    365.00   365.00   365.00    365.00   365.00   365.00
      44.0         344.53   344.00   342.75    344.78   344.78   344.78    365.00   365.00   365.00    365.00   365.00   365.00
      46.0         345.91   345.91   345.91    345.91   357.26   357.26    365.00   365.00   365.00    365.00   365.00   365.00
      48.0         357.26   357.26   357.26    357.26   357.26   357.26    365.00   365.00   365.00    365.00   365.00   365.00
      50.0         357.29   357.29   357.29    357.29   357.29   357.29    365.00   365.00   365.00    365.00   365.00   365.00
```

Table A1 – Main Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES Name	ATTRIBUTES Value Description	CHILD TAGS	TAG DESCRIPTION
ChannelTool	-	-	-	Database Projects Programs	Defines the root name of the data structure
Database	ChannelTool	-	-	Vessel	Defines the vessel specification data structure
Vessel	Database	Name	Identifying name	-	Tag required for each vessel defined in the database
		Type	Vessel type		
		Link	Relative or absolute fully qualified name of the vessel xml data file		
Projects	ChannelTool	-	-	Port	Defines the port project specification data structure
Port	Projects	Link	Relative or absolute fully qualified name of the port xml data file	Name Location	Tag required for each port defined in the database
Name	Port	-	-	-	Name of the design project / port
Location	Port	-	-	-	Location of the design project / port
Programs	ChannelTool	-	-	Geo2Scores Scores Compress Imot NefRisk Access	Root tag for analysis program file locations
Geo2Scores	Programs	Link	Relative or absolute fully qualified name of the program executable file	-	GEO to SCORES file converter executable program
Scores	Programs	Link	Relative or absolute fully qualified name of the program executable file	-	SCORES command (batch) file
Compress	Programs	Link	Relative or absolute fully qualified name of the program executable file	-	COMPRESSXFER executable program
Imot	Programs	Link	Relative or absolute fully qualified name of the program executable file	-	IMOT executable program
NefRisk	Programs	Link	Relative or absolute fully qualified name of the program executable file	-	RISKANALYSIS executable program
Access	Programs	Link	Relative or absolute fully qualified name of the program executable file	-	ACCESS executable program

Table A2 – Ship Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES		CHILD TAGS	TAG DESCRIPTION
		Name	Value Description		
ShipRecord	-	Name	Name of the ship (corresponds to the ship name in the main database)	Condition	Defines the root name of the data structure
		Type	Ship type (corresponds to the ship type in the main database)		
		Geofile	Name of the ship hull geometry (geo) data file		
Condition	ShipRecord	Label	Textual label for the ship condition	Draft (or Trim) Depths Speeds Loading WaveFrequency MotionRisk Squat Points	Defines a ship loading condition data structure root; these is one Condition tag for each ship loading condition defined in the ship databse
		Path	Location of all the ship condition data files		
Draft	Condition	Fwd	Draft in feet at a forward location	-	Specifies the loading condition by two drafts at different points along the ship; a condition is specified by either a Draft or Trim tag
		Xfwd	Location of the forward draft, expressed in stations		
		Aft	Draft in feet at an aft location		
		Xaft	Location of the aft draft, expressed in stations		
Trim	Condition	Angle	Trim angle in degrees, positive bow up	-	Specifies the loading condition by draft and a trim angle; a condition is specified by either a Draft or Trim tag
		Draft	Draft in feet		
		Xdraft	Location of draft, expressed in stations		
Depths	Condition	Begin	Starting water depth in feet	-	Specifies the water depth values used when generating a ship motion transfer function database
		End	Ending water depth in feet		
		Inc	Water depth increment in feet		
Speeds	Condition	Begin	Starting ship speed in knots	-	Specifies the ship speeds used for transfer function calculations; exactly three speeds are required
		End	Ending ship speed in knots		
		Inc	Ship speed increment in knots		
Loading	Condition	Rolldamp	Roll damping as a fraction of critical damping	-	Specifies loading condition parameters and properties
		Kg	Vertical center of gravity in feet, positive up from the waterline		
		Lcg	Longitudinal center of gravity in feet aft of the forward perpendicular		
		Rollgyrad	Roll mass gyradius in feet		
		Yawgyrad	Yaw mass gyradius in feet		

Table A2 (Cont.) – Ship Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES Name	ATTRIBUTES Value Description	CHILD TAGS	TAG DESCRIPTION
WaveFrequency	Condition	Begin	Starting wave frequency in Hz	-	Specifies the wave frequencies used for transfer function calculations
		End	Ending wave frequency in Hz		
		Inc	Wave frequency increment in Hz		
MotionRisk	Condition	Alpha	Motion risk parameter	-	Specifies the acceptable motion risk parameter (see Equation 1)
Squat	Condition	File	Name of the squat and trim data file	-	Specifies an associated data file that defines the squat and trim characteristics of the ship in shallow water
		RelDB	If the RelDB attribute exists, then the file path is treated as relative to the ship project database file location, otherwise it is treated as an absolute path or relative to the main database file location		
Points	Condition	-	-	Primary Alternate	Defines the root tag containing critical point locations
Primary	Points	Clearance	Bottom clearance offset in feet	Point	Defines the root tag containing the five primary critical points
Point	Primary	Id	Point number, integer	-	Defines the root tag for a single critical point; there is one Point tag for each of the five primary critical points
		Label	Point text label		
		X	Longitudinal position expressed as a station number		
		Y	Transverse position, positive to starboard in feet		
		Z	Vertical position, in feet above the baseline		
Alternate	Points	Clearance	Bottom clearance offset in feet	Point	Defines the root tag containing up to four alternate critical points
Point	Alternate	Id	Point text label	-	Defines the root tag for a single critical point; there is one Point tag for each of the (up to) four alternate critical points
		Label	Point text label		
		X	Longitudinal position expressed as a station number		
		Y	Transverse position, positive to starboard in feet		
		Z	Vertical position, in feet above the baseline		
XferDB	Condition	-	-	Depth	Defines the root tag containing the ship motion transfer function database

Table A2 (Cont.) – Ship Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES		CHILD TAGS	TAG DESCRIPTION
		Name	Value Description		
Depth	XferDB	Value	Water depth in feet	-	Specifies a single transfer function database record for a specific water depth; there is one Depth tag for each transfer function in the database
		V1	First ship speed in knots		
		V2	Second ship speed in knots		
		V3	Third ship speed in knots		
		Infile	File name of the SCORES input file		
		Binfile	File name of the binary transfer function file		
		Status	Status indicator; =0 when in undefined state, =1 when in ready state, =-2 when the loading or mass property information has changed, =3 when the ship geometry has changed		
		Exists	=1 when CADET assumes the transfer function file exists; =0 when the transfer functions have not been created		

Table A3 – Ship Geometry Data File Description

RECORD	NAME	FIELD NAME	DATA TYPE	DESCRIPTION
1	Title		Character	Identifying name
2	Ship Characteristics	Number of Stations	Integer	Number of subsequent transverse sections defining the hull – MUST be 21[2]
		Lpp	Real	Length between perpendiculars
		Station Spacing	Real	Spacing between stations
		Units	Integer	=0 for english units =1 for metric units
3	Station Identifier	Number of Points	Integer	Number of subsequent points defining a station
		Station Number	Real	Station number, starting at zero at the forward perpendicular and 20 at the aft perpendicular
4	Station Curve Point	Half Breadth	Real	Offset distance from the centerline
		Vertical Height	Real	Offset distance above the baseline
		Point Type	Integer	=0 (or blank) normal point =55555 end line point =66666 start line point =77777 break point =88888 end point

[2] Due to limitations in the geometry conversion program (GEO2SCORES)

Table A3 (Cont.) – Ship Geometry Data File Description

RECORD	NAME	FIELD NAME	DATA TYPE	DESCRIPTION
5	Bow Profile Curve	Number of Points	Integer	Number of points defining the bow profile curve
6	Bow Profile Point	Longitudinal Position, station	Real	Offset distance aft the forward perpendicular, expressed as a station number
		Vertical Height	Real	Offset distance above the baseline
		Point Type	Integer	=0 (or blank) normal point =55555 end line point =66666 start line point =77777 break point =88888 end point
7	Stern Profile Curve	Number of Points	Integer	Number of points defining the stern profile curve
8	Stern Profile Point	Longitudinal Position, station	Real	Offset distance aft the forward perpendicular, expressed as a station number
		Vertical Height	Real	Offset distance above the baseline
		Point Type	Integer	=0 (or blank) normal point =55555 end line point =66666 start line point =77777 break point =88888 end point

Table A4 – Transfer Function Comparison Data File Description

RECORD	NAME	FIELD NAME	DATA TYPE	DESCRIPTION
1	Number of Data Sets		Integer	Number of sets of transfer functions in the file
2	Length	Ship Length	Real	Length of the ship for these transfer functions
3	Title	Transfer Function Set Title	String	Title used for an individual set of transfer functions - subsequent sets repeat records 3, 4, 5, and 6 as needed
4	Data Type and Units	Data Type	Integer	=0 if transfer functions are non-dimensional (pitch and roll by wave slope), otherwise, pitch and roll are dimensional
		Data Units	Integer	=0 if dimensional transfer functions (pitch and roll) are degrees/wave height, otherwise, pitch and roll are assumed in radians/wave height
5	Number of Frequencies		Integer	Number of frequencies or wave lengths
6	Transfer Function Data	Omega	Real	Wave frequency, Hz – record 6 is repeated according to record 5
		Omega Encounter	Real	Encounter wave frequency, Hz
		Wave Length	Real	Non-dimensional wave length, ship lengths
		Heave Amplitude	Real	Heave amplitude
		Heave Phase	Real	Heave phase, deg
		Pitch Amplitude	Real	Pitch amplitude, according to the data type and units flags
		Pitch Phase	Real	Pitch phase, deg
		Roll Amplitude	Real	Roll amplitude, according to the data type and units flags
		Roll Phase	Real	Roll phase, deg

Table A5 – Project Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES		CHILD TAGS	TAG DESCRIPTION
		Name	Value Description		
ProjectRecord	-	Name	Name of the project (corresponds to the project name in the main database)	Reach Selection Comment Report	Defines the root tag of a project database
		Location	Location of the project (corresponds to the project location in the main database)		
Reach	Projectrecord	Name	Identifying name for the reach	Wavedata	Specifies a single channel reach; there is one Reach tag for each channel refined for the project
		Length	Length of the reach, NM		
		Direction	Outbound heading of the reach, deg		
		Width	Width of the channel, ft		
		startDepth	Initial water depth, ft		
		endDepth	Final water depth, ft		
		incDepth	Water depth increment, ft		
		Over	Over dredge amount, ft		
		Variance	Variance in the bottom level, ft		
		Bottomtype	Descriptive name of bottom type		
		waveCofvar	Coefficient of variation in wave data		
Wavedata	Reach	File	Name of the wave spectra data file	-	Specifies a wave spectra data file associated with a project reach; there one Wavedata tag for each wave condition defined
		Swh	Significant wave height, ft		
		Period	Modal period, sec		
		Dir	Dominate direction, deg		
		Prob	Probability of occurrence		
Selection	Projectrecord	-	-	Condition	Specifies a ship selected for consideration in the channel design analysis; there is one Selection tag for each ship selected for the project
Condition	Selection	shipLink	Name of the ship database file	-	Specifies a particular ship loading condition selected for consideration in the channel design analysis
		condLink	Name of the ship loading condition		
Comment	Projectrecord	-	-	-	Specifies textual comments to be maintained with a project configuration
Report	Projectrecord	Path	Name of the subdirectory where results database is located	-	Specifies a channel analysis results report created; there is one Report tag for each report in the project database
		Created	Data and time that the results database was created		

Table A6 – Results Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES Name	ATTRIBUTES Value Description	CHILD TAGS	TAG DESCRIPTION
CADET_Report	-	Created	Data and time that the report was created	Reach Ship	Defines the root tag for a channel analysis results report
Reach	CADET_Report	Name	Identifying name for the reach	WaveData	Specifies a single channel reach; there is one Reach tag for each channel refined for the project
		Length	Length of the reach, NM		
		Direction	Outbound heading of the reach, deg		
		Width	Width of the channel, ft		
		startDepth	Initial water depth, ft		
		endDepth	Final water depth, ft		
		incDepth	Water depth increment, ft		
		Over	Over dredge amount, ft		
		Variance	Variance in the bottom level, ft		
		Bottomtype	Descriptive name of bottom type		
		waveCofvar	Coefficient of variation in wave data		
WaveData	Reach	File	Name of the wave spectra data file	-	Specifies a wave spectra data file associated with a project reach; there one Wavedata tag for each wave condition defined
		Swh	Significant wave height, ft		
		Period	Modal period, sec		
		Dir	Dominate direction, deg		
		Prob	Probability of occurrence		
Ship	CADET_Report	Name	Name of the ship (corresponds to the ship name in the ship database)	Condition	Specifies a ship used in the channel design analysis; there is one Selection tag for each ship selected for the project
		Type	Ship type (corresponds to the ship type in the ship database)		
		StSp	Station spacing, ft		
Condition	Ship	Label	Condition name	Draft (or Trim) Speeds MotionRisk Loading Squat Points XferFn	Specifies a particular ship loading condition
Draft	Condition	Fwd	Draft in feet at a forward location	-	Specifies the loading condition by two drafts at different points along the ship; a condition is specified by either a Draft or Trim tag
		Xfwd	Location of the forward draft, expressed in stations		
		Aft	Draft in feet at an aft location		
		Xaft	Location of the aft draft, expressed in stations		

Table A6 (Cont.) – Results Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES Name	ATTRIBUTES Value Description	CHILD TAGS	TAG DESCRIPTION
Trim	Condition	Angle	Trim angle in degrees, positive bow up	-	Specifies the loading condition by draft and a trim angle; a condition is specified by either a Draft or Trim tag
		Draft	Draft in feet		
		Xdraft	Location of draft, expressed in stations		
Speeds	Condition	Begin	Starting ship speed in knots	-	Specifies the ship speeds used for transfer function calculations; exactly three speeds are required
		End	Ending ship speed in knots		
		Inc	Ship speed increment in knots		
MotionRisk	Condition	Alpha	Motion risk parameter	-	Specifies the acceptable motion risk parameter
Loading	Condition	Rolldamp	Roll damping as a fraction of critical damping	-	Specifies loading condition parameters and properties
		Kg	Vertical center of gravity in feet, positive up from the waterline		
		Lcg	Longitudinal center of gravity in feet aft of the forward perpendicular		
		Rollgyrad	Roll mass gyradius in feet		
		Yawgyrad	Yaw mass gyradius in feet		
Squat	Condition	File	Name of the squat and trim data file	-	Specifies an associated data file that defines the squat and trim characteristics of the ship in shallow water
		RelDB	If the RelDB attribute exists, then the file path is treated as relative to the ship project database file location, otherwise it is treated as an absolute path or relative to the main database file location		
Points	Condition	-	-	Primary Alternate	Defines the root tag containing critical point locations
Primary	Points	Clearance	Bottom clearance offset in feet	Point	Defines the root tag containing the five primary critical points
Point	Primary	Id	Point number, integer	-	Defines the root tag for a single critical point; there is one Point tag for each of the five primary critical points
		Label	Point text label		
		X	Longitudinal position expressed as a station number		
		Y	Transverse position, positive to starboard in feet		
		Z	Vertical position, in feet above the baseline		

Table A6 (Cont.) – Results Database XML Tag Descriptions

TAG NAME	PARENT TAG	ATTRIBUTES Name	ATTRIBUTES Value Description	CHILD TAGS	TAG DESCRIPTION
Alternate	Points	Clearance	Bottom clearance offset in feet	Point	Defines the root tag containing up to four alternate critical points
Point	Alternate	Id	Point text label	-	Defines the root tag for a single critical point; there is one Point tag for each of the (up to) four alternate critical points
		Label	Point text label		
		X	Longitudinal position expressed as a station number		
		Y	Transverse position, positive to starboard in feet		
		Z	Vertical position, in feet above the baseline		
XferFn	Condition	Value	Water depth in feet	-	Defines the root tag containing the ship motion transfer function database
		V1	First ship speed in knots		
		V2	Second ship speed in knots		
		V3	Third ship speed in knots		
		Infile	File name of the SCORES input file		
		Binfile	File name of the binary transfer function file		
		Status	Status indicator; =0 when in undefined state, =1 when in ready state, =-2 when the loading or mass property information has changed, =3 when the ship geometry has changed		
		Exists	=1 when CADET assumes the transfer function file exists; =0 when the transfer functions have not been created		

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